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**MARY KATHLEEN BENNETT**

**H9018357**

**Investigating Teacher-Pupil  
Oral Communication in Mathematics  
at Key Stage Two.**

**DOCTOR OF EDUCATION (EdD)**

**September  
2001**



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# Investigating teacher-pupil oral communication in Mathematics at Key Stage Two.

## **Abstract**

The dissertation sets out to investigate how teacher-pupil communication can be used to establish and build on key stage two pupils' perceived understanding in order to enhance learning in Mathematics. Conclusions are drawn after examining lengthy discourse between one adult and nine children. After discussing facets of constructivism, the concentration is on the relationship between the use of situated cognition and an understanding of pattern in mathematics. The conclusion drawn is that a developing grasp of pattern is helpful for children whose thinking may still be of a concrete nature, in order for them then to calculate successfully in a hypothetical situation. Communication, primarily of an oral nature, is examined in order to determine how an adult in the teaching situation might enhance the understanding of that pattern, two approaches being highlighted as of particular value, the use of speculation and silence. The use of initiation, response and feedback sequences and open questioning can also be seen to be helpful in certain circumstances. The conclusion is drawn that whatever the oral technique in use, it is the teacher's ability to listen to the child which is paramount if they are to make appropriate interactions in relation to pupil understanding.

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## PART ONE: INTRODUCTION AND AIMS

This dissertation came out of a study where I investigated teachers making assessments of pupil learning. One question that I began to ask myself was what might be going on for the pupil when the teacher was talking with them in order to find out what they knew and understood. I surmised that the pupil might be structuring their understanding, thus learning, as they were required to sort out in their own minds what they knew and then demonstrate it to the teacher. If they were learning, I asked myself whether there was there a question of how the teacher could talk to pupils in a way that would best enhance that learning, not just when assessing, but in the normal course of discussion between teacher and pupil. This was a matter I wished to pursue further.

My original motivation for wishing to pursue the matter of discussion in teaching was further stimulated by concerns expressed by Neville Bennett (1984) and his co-researchers in 'The Quality of Pupil Learning Experiences', and Mary-Jayne Drummond (1993) in 'Assessing Children's Learning'. They found during their research that teachers tended to look at the product of the work rather than at the process undergone in producing it. Moreover, when an error was found, the teachers would take the learner step by step through the manual procedure necessary for producing correct work, rather than diagnosing where there was a misunderstanding and tackling the conceptual problem underlying the wrong result.

There might be more value in teachers providing less direct instructional input and adopting a more diagnostic stance, thus allowing the child to exhibit his errors.

(Bennett *et al.* 1984 p 172)

Mary-Jayne Drummond observed:

Teachers who investigate, for example, children's mathematical thinking, by listening to their pupils' thinking aloud, explaining their calculations, very quickly discover that apparent errors in the written record of those calculations are often the result of systematic mathematical reasoning, which has been mistakenly applied.

(1993 p 91)

A question by Robin Alexander (1995) "How, in short, can we use classroom dialogue as a means of promoting genuine learning and understanding?" (p 209) addresses a similar dilemma to the concerns being raised in my own mind. Therefore, by talking with some children, I set about the task of answering the following question: "How can teacher-pupil communication be used in the teaching situation to establish and build on pupils' perceived understanding and thus enhance learning?"

### **History of my study**

I hoped that in my study I would identify new understanding and skills which have the potential to enhance the curriculum practices of those involved in education, in particular, my own. By doing so, I would have fulfilled one of the line-specific criteria for this Doctorate. As a recently retired primary school headteacher with many years experience, but still involved in education, my concern is that the curriculum offered to children, by myself and others, is made as efficient as possible. Originally, I planned to work with a small group of year five children I taught in the school where I was headteacher by reflecting on how I interacted with them in the group and individually. However, through circumstances beyond my control, I found myself no longer at the school, so I linked up with a neighbouring Junior school, which I call Seaview School, continuing to opt for working with pupils initially in year five. I chose the domain of Mathematics and within that the gaining of an understanding in number. This is a crucial area of competency because of our need to use calculations in order to operate



successfully in our culture. If reports are to be believed, it is also one in which students leave our schools without that need met to a satisfactory extent. Dr Tony Gardiner, President of the Mathematical Association, writing in the Times Educational Supplement 4th April 1998, says, "Our weakness in "number" raises serious questions about older pupils' ability to develop subsequently in other areas of mathematics and science" (p 22). My hope is that my study might make some small contribution to alleviating this state of affairs.

The move from reflecting on work undertaken in my own school in the normal course of events to working with individuals and groups withdrawn from their own class and teacher in a school where I had no official role raises the issue of whether I acted as a teacher or researcher in that context. My original plan was to seek a contribution to pedagogical studies through my teaching. Schools today are places where a number of adults, not all holding the title of 'teacher' have an input into the learning of the pupils. I was one more person having such an input, albeit limited, into the learning of the children with whom I worked. If the definition of a 'teacher' is a person who facilitates learning I very much hope that my efforts had that effect. In that respect I could be said to be teaching. However, Janet Ainley (1999) gives the difference between a teacher and a researcher, in a situation such as the one in which I was acting, as being one of purpose. Was I more interested in the welfare and learning of the children or was I more interested in finding out more about issues pertinent to my research question? Whilst I was interested in doing the best I could for the children when speaking to them, the answer has to be the latter, and therefore I acted as a researcher, though one informed by years of teaching. The topics chosen by me for discussion, following the initial conversation, were partly taken because I felt they could produce data relating to the issues raised in that first discussion. However, as Ainley says, "I know how to dress and behave, I know the appropriate ways to speak to children, I have some strategies for getting and holding the attention. ... These things make it easy for me to be seen as a teacher" (1999 p 46). I write further on page 72 of how far I felt the children took me as a teacher. I believe that it was

important that they should view me as someone having a teaching role if the outcomes from our conversations were to have any relevance to the task of enhancing learning in school situations which will take place elsewhere. Whilst in the school I was afforded the status of a teacher by the staff and, in my view, acted as a classroom assistant, many of whom are now expected to take part in small group teaching under the direction of the class teacher.

A further consideration is whether this dissertation, which chronicles the outcomes from our discussions, can be regarded as purely a 'tale that is told' or a compilation of issues which appeared to me to be of some importance to the world of oral education. I would claim the latter because, although it contains narrative describing a series of conversations, I have been selective in the choice of excerpts presented. The choices were made as I felt these had a relevance to issues related to possible improvement in pedagogy. It is the exploration of a series of issues which transform narrative into research.

In all, I worked with nine children, at length, making possible a study of complex interactions taking place in the course of our conversations, over a period of time. The focus was on my developing insights into the way I facilitated their learning, insights which it is hoped will encourage other teachers to consider a similar facilitating stance. The expected advantage of such an approach was that I could spend time developing a close understanding of the way individual pupils were responding. By taking a range of pupils, by gender and ability, I wanted to be able to highlight some of the differences in approach a teacher might need to adopt with different pupils, but found this difficult to achieve when working with more than one pupil at a time. However, this is the reality of the educational world and I believe my work has relevance for teachers working with children of a similar age and in the same domain.

What emerged as a result of my study was an awareness that, whatever strategies were used, the essential factor was the ability of the adult to actively listen to the child, what they said, how they said it and even what they omitted to say. Strategies explored included aspects of posing

questions; of making space for children to compose their contributions to conversations and the posing of inputs in the form of suppositions. In addition, I reached a conviction that children can misunderstand problems set in fictional, but supposedly lifelike situations.

The format was one of a case study, a looking at a single situation in depth. O'Hanlan (1996) writes, "How can the teacher control, much less dictate, the impact they have in educational contexts without self-knowledge and understanding?" (p 85). By reflecting on my practice, my operations in a social setting, I constructed an understanding of the impact my interactions had on the children.

### **Research question**

The specific question I wished to address was:

How can teacher-pupil communication be used in the teaching situation to establish and build on pupils' perceived understanding and thus enhance learning?"

I intended to seek answers in order to improve my own practice, add to existing research and make some contribution to the ability of any teacher reading the study to enhance the learning of their pupils. By talking with children about the domain of Mathematics, I hoped it might be possible to identify approaches, both pertaining to the subject matter and the manner of conversation, which would give me, and other teachers, pointers to contribute to our consideration of pedagogical issues.

Neil Mercer (1995) writes, "To be effective any teacher needs to explore the scope of a learner's existing knowledge" (p 10). This is a statement with which I agree totally because without it it is not possible to build on that understanding. Both are important and in my conversations I endeavoured to do just that, but not always with complete success, as will be seen during my analysis of data. Maybe it is not possible because no one can enter into another's thinking completely, an issue within radical constructivism which I examine later in my literature section. I do not feel that it would be possible for any person, even a teacher, to know whether they have made an

accurate assessment of the pupil's understanding, or whether they are making the best possible contribution to building on that understanding, but the issues which emerged from my conversations relate to how one might, in the role of a teacher, use oral communication more productively. I worked in the realm of 'perceived understanding', rather than 'actual understanding'. It is very possible that a teacher's perception of the understanding of their pupils is faulty and therefore their response becomes less than completely helpful, even possibly confusing. It is possible that the perceptions, on the part of the teacher, are accurate but their response to a pupil unhelpful. It is also possible that their perceptions are accurate, the response appropriate but that the pupil's learning is not enhanced. This needed to be investigated.

The title of my dissertation and my research question include the phrase 'teacher-pupil communication' because, by my work, I aim to shed light on the activity of the adult in the teaching role. Thus, the emphasis is on the behaviour of the 'teacher'. However, it has to be recognised that communication is two-way, and the more important aspect is the reception of pupils' contributions by the teacher, used as a pre-cursor to their response. Teachers need to be actively listening, and this need will emerge as crucial in my analysis of data.

In order to communicate, the pupil and teacher need some form of shared understanding. Since the communication is often verbal there is a need for a degree of agreement about the meanings of words used by them. Ernst von Glasersfeld maintained that all our word meanings are partially subjective, abstractions based upon our past experiences of particular words.

For communication to be considered satisfactory and to lead to what we call 'understanding', it is quite sufficient that the communicators' representations be compatible in the sense that they do not manifestly clash with the situational context or the speaker's expectations.

(Glasersfeld, 1989, p 9)

I looked for insights into how far the children and I showed agreement in the way we responded to each other's meanings as I analysed my data.

The joint and mutual use of language gives us a huge step in the direction of understanding other minds. For it is not simply that we all *have* forms of mental organisation that are akin, but that we *express* these forms constantly in our transactions with one another. We can count on constant transactional calibration in language, and we have ways of calling for repairs in one another's utterances to assure such calibration.

(Bruner 1987 p 87)

As I worked, I was looking for an understanding of how I, as the adult, and the children were 'repairing each other's utterances', so that those utterances made sense to the recipient and led to calibration, or a process of mutual building upon each others' words.

The domain in which the learning was intended to take place was that of Mathematics and, as I reflected on our discussions about number, I came to the conclusion that not only was it helpful to learning for the adult in the teaching role to adopt certain strategies of discourse, but the way the material was presented was relevant. I write later, in both parts two and four, of my conviction that patterns in number should be grasped by pupils and that once they have formed various concepts about mathematical relationships they are then in a position to apply them to hypothetical, situational problem solving. This is in opposition to expecting the situational setting to enhance understanding.

Part two examines my chosen theoretical framework as reflected in the existing literature; part three presents my methods of investigation; part four contains my findings whilst part five considers implications for further work. It is my earnest hope that practitioners and researchers will find something to stimulate them to further investigation of the strategies and approaches I advocate.

## PART TWO: LITERATURE REVIEW

My study, with a focus on the construction of meaning, is about understanding, interaction with content, linking of ideas and relating evidence to conclusions. As Stones says:

New learning involves the re-structuring of existing thought processes, not just the piling up of new ideas. Learners demonstrate that they have successfully integrated their new with their previously learned concepts into new, more complex cognitive structures by applying the new learning successfully in ways they could not have done previously.

(Stones, 1992, p 26)

Learning is not about the ability to reproduce content, passive acceptance and lack of reasoning. The learning Stones advocates I connect with constructivist views and this is the context in which this dissertation is set. I begin there, by looking at how people, and children in particular, can be helped to construct their understanding, to learn. I follow this by examining the domain of Mathematics and how pupils can operate within it before discussing strategies of discourse because I believe that language is a vital medium for enhancing that learning.

### **Learning**

#### *A social-constructivist view*

Mercer (1995) maintains that talk is a social action and through it knowledge can be constructed. He is supported by claims such as, “conversation lies at the heart of learning: learners are listeners as well as speakers; partakers of a discourse that is itself an act of social creation” (Ranson *et al.* 1996 p 17). These are views of learning in the social constructivist tradition and follow in the train of psychologists such as the Soviet Psychologist, L.S. Vygotsky, working in the 1930s, who maintained that:

Thought development is determined by language, i.e. by the linguistic tools of thought and by the sociocultural experiences of the child. Essentially the development of inner speech depends on outside factors; the development of logic in the child...is a direct function of his socialised speech. The child's intellectual growth is contingent on his mastering the social means of thought, that is language.

(in Stierer and Maybin, 1994, pp 46-47)

If it is as the quotation says, it is necessary for the child to be able to debate, either with him or herself, or with another person, in order to construct an understanding of the world around them. How can the child debate if they do not have the vocabulary? The child can only acquire the vocabulary from other users of the language in which the debate takes place. If the other users are skilled in engaging the child in socialised speech such that he or she develops logical thought and, thus, intellectual growth the thought processes of the learner continue to expand and become more sophisticated. Therefore, the understanding has unending potential, so long as it relates to the experience of the child. If that learner has nothing within his or her schemata upon which to draw, they have no connection with the debate. They cannot engage with it at all. If they are given the connection, their intellectual growth can begin. The quotation from Vygotsky would seem to indicate that there is no limit to what the child could understand, given a mastery of language and the stimulation of social interaction, although my interpretation of the quotation, taken out of context, may misrepresent him.

Child (1993) says that Vygotsky views concept formation as having three stages: vague syncretic, which is random; complexes where the child holds attributes of a concept which are not necessarily held by others; and the third stage, the potential concept stage, dealing with one attribute at a time. It is only when all attributes can be held in balance that a concept is said to have matured. Child goes on to say that we must beware of throwing too many verbal labels at children, pseudo concepts, which they use, giving the

appearance of understanding. It is one thing giving them the vocabulary of debate, as written above, it is another to ensure they can set that vocabulary in a correct conceptual framework. It is vitally important for the teacher to listen to the detailed context in which the learner uses a word in order to discern that child's understanding. It is necessary to ensure that attributes of concepts are being used in debate, or discussion, so that they may be grasped by the learner and contribute to the formation of a mature concept within the learner's mind.

The idea of stages would seem to parallel the thinking of those who, whilst acknowledging the role of language, hold to Piaget's concept of a growing decentration as a child moves towards teenage years, a move from thinking in the concrete to the abstract. Vygotsky's stages are not of chronological maturity but are those of concept formation in a child who could actually progress through them quite rapidly, given suitable stimuli and support. I discuss the identification of the development of concepts within my work in part four, coming to the conclusion that the evidence is sparse, owing to the number of concepts covered and the amount of input from any particular child. This is an area for further investigation.

Barnes (1976) aligned himself with Piaget's thinking and claimed that the young child cannot stand outside themselves and analyse their thinking. They cannot reflect. In addition, they find it difficult to project into another's point of view. I am not sure I fully agree because it is necessary to examine at what stage of conceptual development one might expect children to engage in metacognition, reflecting on their own learning, and decentering, able to grasp the point of view of another person, to follow the reasoning presented. It may well be that it is not the age of the child that is the criteria demarcating the ability to reflect but the intellectual development which has to do with the stimulation they have received. Barnes himself said, "it is for teachers to ask themselves how they can help pupils to achieve reflective talk and writing" (1976 p 31). "It is not that the child does not have the capacity to take another's perspective," said Bruner (1987 pp 92-93), but he did add that it is something which has to develop. In fact, he



went further “The child’s use of language rests on her ability to appreciate the perspective of others” (Bruner and Haste 1987 p 2). I would agree. It is as the child understands the context for their thinking that they have the ability to locate their partial understanding in the wider picture. They then have the confidence to integrate related aspects, as conveyed to them by other people. Much more recently, Torrance and Pryor (1998) state that children need to engage in metacognition, the thinking about thinking, in order to gain an overview of the learning activity (p 157) so, for them, not only can children engage in this higher mental activity, but they should, in order for their understanding to enlarge, and be set in context, as far as their schemata allow.

It is only as we assimilate the utterances of others and their reasons for such comments that we can adjust our thinking to accommodate their ideas. This is so for the child. They need to be able to adjust to the teacher’s perspective, even if the emphasis of the conversation is within their agenda. As Stephen Lerman (1996) maintains, it depends on the pupil’s conceptual structures as to how these are modified by the experiences arranged by teachers in the school setting. I would add that it also depends on how far the pupil is encouraged to organise input from experience, and thus modify schemata through language. A small example of this was when I asked one of the children with whom I worked, Jay, to label digits in a number. We were able to draw on that experience in order to help him clarify the role of zero in delineating the value of a digit (Jay 22.2.98 pp 3-5).

In my study I frequently asked children to explain their thinking, to reflect back on their work. I do not think I was expecting the impossible. White (1992) would insist that the learner must engage in metacognition, reflecting on their thinking, if quality learning is to take place. Much of what I write in sections two and four about teachers adopting a stance of uncertainty requires children to follow the thinking of the teacher and then to draw from their own understanding the relevant knowledge to answer the conjecture. This requires reflection on what is known by pupils as they select what they

need. It also requires the child to seek to put the supposition into the likely context being engaged by the teacher.

### *Radical Constructivism*

Before considering how it is that a teacher can interact with pupils in order to support their construction of understanding, it is necessary to ask what form those constructs may take. Can the child acquire constructs which are paralleled in society? Does the child come to understand mathematical concepts which are those commonly held, such as percentage, or does each learner construct their own concepts, unique to them, as a result of their own experiences, hypotheses and reflections? Much of my work involved seeking to encourage within the children a conceptual framework which is the same as, or at least similar to, those held by others, so this question is of importance. E von Glasersfeld (1994) maintains that mental operations cannot be witnessed by another, the other can only appreciate the results of those mental operations. Thomas (1994) goes further. He says that it is impossible for the constructs of two people to be compared. Kamii and Warrington (1995) state that:

children do not learn logico-mathematical knowledge by transmission from their peers or teachers. Social interaction can stimulate critical thinking, but the thinking itself (logico-mathematical knowledge) must be done by each individual.

(Kamii and Warrington, 1995, p 60)

If you are to be true to radical constructivism, you have to accept the possibility that there is no real world, or if there is, that it cannot be known for certain, maintains Jaramillo (1996). All might be a figment of our personal understanding or not humanly knowable outside our own perception. I am not sure that if you hold to the idea that each person's constructs and concepts are unique it has to follow that all being is within the mind. The world systems and social structures may be human-made, continually shifting, and human understanding, collectively, may change. However, that does not mean that there is not a stable entity which is outside

our constructs. Moreover, if personal constructs are unique there would be no guarantee that the results of communication, even if they were the same, had been derived as outcomes from similar mental operations. If this were to be the case a teacher seeking to lead a pupil through a series of cognitive processes to a given outcome would be working in conflict with those taking place within the pupil.

Ormell (1995) says, of the views of von Glasersfeld (1994) and Thomas (1994), that leaving children to construct their own understanding is like throwing a jig-saw down in front of them and leaving them to put the pieces together in some semblance of order, without knowing what the picture should be. I feel he overstates the case. Teachers will present pupils with an environment which is conducive to their learning a concept in an intended way. It is beholden on teachers to seek, through social interaction involving, primarily, the senses of sight, hearing and touch, as well as the gift of language, to encourage learning. Children are not left to make sense of the world on their own. Ormell (1995) advocates 'exemplary lucidity' as the way of presenting material to pupils, of teaching by example, but what may be lucid to the teacher may not be to the pupil whose constructs have similarities with the teacher's, but also areas of difference or incompleteness.

Whilst a complete divergence of constructions may not be true for teacher and pupil, there does need to be a meeting of their minds in the way described below. Constructs may vary, but certain concepts have to be held in common if there is to be any communication at all. Conservation of number may well be one such example, a concept through which mathematics is regulated. Society would founder if we did not agree on using one to one correspondence. How could we ensure that the right number of tickets had been issued for a concert, for instance? If there are mathematical concepts held in common by members of society, then there must be commonly-held constructs supporting these concepts. One example would be the operation of base ten as the foundation of calculation in twentieth/twenty-first century western society. Without a working

knowledge of the constructs, learners remain confused when seeking to follow calculations. I have used examples from the domain of Mathematics but within other domains, such as science and history with its concept of change, there are surely similar examples. Bonnett (1994) emphasises:

the whole of social life, including language and the accumulated knowledge and understanding of a culture, is based on a structure of publicly shared conventions, i.e. rules.

(Bonnett, 1994, p 51)

Whilst pupils need to construct an understanding for themselves, that understanding needs to accord with the “rules” set by society if they are to operate as a member of it. The dilemma remains as to how societal “rules” and individual constructs can be brought into harmony, where that is needed in order for that person to operate within the society.

It behoves the teacher to identify essential constructs, to referee their’s against society’s and when agreement has been assured, so far as is possible, to seek to ascertain the state of the pupils’ constructs, to identify differences and endeavour to support those learners in the task of embracing the constructs for themselves. In the process, the pupils may well enrich the exchange of ideas from their own insights. The teacher would then be operating to a social constructivist frame of reference. Ernest (1994) sees that as a central issue, “how to reconcile the private mathematical knowledge, skills, learning, and conceptual development of the individual with the social nature of school mathematics” (p 304). It would be difficult for the teacher to establish a grasp of the pupil’s constructs if there were the possibility of infinite variation. Bonnett goes on to write that understanding is demonstrated by the ability of a person to follow a rule. If a person is able to follow the rules inherent in operating in base ten, for instance, by moving a digit one column to the left when multiplying by ten, then one can say they are developing the capacity to think in accordance with a guiding principle. If the pupil makes errors, in relation to that principle, then the teacher needs to analyse those errors in order to see whether there is a

pattern which reveals a partial grasp of the construct, or indeed whether the pupil has a contribution to make to the development of that same construct. Such is the role of formative assessment, the establishing of perceived understanding, which is a central part of my research question.

By following the guiding principle which is commonly held by society, a person has a frame of reference by which they can communicate with others. If they purely follow their own constructs and develop rules for themselves, communication becomes fraught. Rule-following makes it possible for constructs to be held by more than one person. That idea is at variance with the view Jaramillo (1996) attributes to Vygotsky; a view which says that teachers should be facilitators to student self-developed concepts. Vygotsky does advocate a teacher being sensitive to the understanding of a student and providing support as the student deepens their understanding, but that does not preclude the teacher having an end view in mind, and, as Jaramillo goes on to say, “the curricula should reflect both parties’ interests” (p 136). Did Vygotsky really hold a radical position? I think not. He said, “to understand another’s speech it is not sufficient to understand his words we must understand his thought” (in Stierer and Maybin 1994 p 50). We can only understand another’s thought if we share an understanding of certain concepts. Individualised concepts, such as methods of calculation, may well be developed and continue to be held without detriment to that person’s operation within society. That is, so long as it gives adherence to ‘rules’ within the domain, such as place value. In addition, however closely the teacher’s and pupil’s concepts align, the teacher should endeavour to be supporting the learning of the pupil.

### *Supporting Learning*

I see ‘supporting learning’ as the process by which the teacher paces the amount of help given to a child, in whatever form, based on their moment by moment assessment of the child’s need. For example, whilst working with the children as part of this study, there were times when I allowed them to explain what they thought. Elsewhere we engaged in sessions of my

initiation of the subject, a response from them and then feedback where the support I was giving was much greater.

Bruner (1985) offered the picture of a teacher limiting the complexity of a task to one the child can just manage. He went on to define the role of instruction as help coming after a child knows how to tackle a problem; telling the child what to do, or what he might try next; or showing what is inhibiting him. This is one way of responding to understanding. Other suggestions include keeping the pupil on task with the goal clearly in view; highlighting critical features of the task; or demonstrating how to achieve a goal, all with the minimum of help necessary.

If a teacher allows a pupil to explain their thinking or questions and gives feedback following a response in order to check they have understood the pupil correctly, they are likely to be conducting those activities verbally. Therefore, these strategies form ways in which the teacher might use an oral interchange to arrive at perceived understanding in order to support the process of enhancing the pupil's learning. Not only does the teacher need to begin a dialogue with an accurate view of the child's understanding, but he or she needs to be ready to adjust the level of verbal support based on an ever-changing assessment of the learning taking place.

Instructionally effective teaching may therefore be more appropriately viewed as involving the continuous assessment of pupils' competencies.

(Calderhead, 1984, p 52)

Calibration occurs when teacher and pupils test their understandings against those held by the other, and adjust their utterances in order to make them accessible to each other.

(Cooper and McIntyre, 1996, p 118)

Both of these references, written twelve years apart but giving a similar message, focus attention on the activity of moment by moment adjustment

by both teacher and pupil as they engage in dialogue to the end purpose of enhancing the pupil's learning. The learning should then lead to 'handover', the time when the pupil can operate independently of the teacher.

The essence of the process is that learners do not remain for ever propped up by the scaffolding of adult assistance, but come to take control of the process for themselves.

(Edwards and Mercer, 1987, p 23)

Bonnett (1994) points out that it was only when a pupil carried on unaided that we could say they had demonstrated understanding. I found that, in my work with children for this dissertation, I tended to stop the work too soon, satisfied with a joint success in solving a given problem. I needed to give more thought to follow-up without losing pupil motivation. I needed to know how much support to give at any one time so that the children could make connections with existing schemata, but not giving so much of my own constructs that they could not assimilate what was being said. The wrong amount either way can lead to frustration (Wood and Wood 1996). Frustration, in its turn, can lead to lost motivation. Motivation loss lessens the productive learning as the learner has little desire to make connections with existing knowledge.

The frustration is related to a loss of self-esteem, as the learner fails to perform as they expect. We all have a need to succeed, as is drawn out by Child's (1993) comments on Maslow's hierarchy of need (pp 45-46). We desire the enjoyment of success and seek to avoid the unpleasant feelings of inferiority, weakness or helplessness associated with failure.

The point at which learners take full control is a matter of debate. White (1992) says that an essential aspect of metacognition, thinking about thinking, is that learners take control of their thought processes, which are independent of the teacher, to a substantial degree. This puts a considerable strain on the teacher who is seeking to support the learning, but not take over control. I found that, during this research, in the first round of conversations with each child, we were working almost wholly to my

agenda. White would regard this as a threat to quality learning because of the point made earlier about losing connection with the child's constructs. The dilemma is that I, as the adult, have been exposed to the domain in which we are working for longer than the child and am anxious to see that their learning does not lead them away from socially accepted 'rules'.

Bruner (1985) used the word, 'scaffolding' to describe the work of a tutor, be they an adult or more competent peer, in serving the learner as a vicarious form of consciousness until the learner is able to achieve conscious control over their new function or conceptual system. As I was working with learners, I found myself holding onto the whole task whilst the learner came to terms with an aspect of it, then rehearsing back to them the larger task and where the aspect upon which they had just been working fitted into it. An example was when I said, "How many eights in a thousand? We've got twelve remainder four in one of those ... squares. You said there are ten of those squares, so how many eights in ten of those squares?" (Jay 30.10.97 p 13). Bruner goes on to write about limiting the complexity of a task to the level with which a learner can cope, filling in the rest until the learner can tackle more of the activity or concept.

During my research, I became convinced of the need for teachers to have worked out very carefully interconnecting pathways of small steps in understanding so that whichever pathway the learner chose to take, the teacher could guide them along it in manageable increments, whilst they hold on to the ultimate destination for that learner. The teacher would need to have identified the attributes of a concept and to have presented them one at a time whilst the child is working through Vygotsky's potential concept stage to maturity (Child 1993). Wood and Wood (1996) also highlight the fact that the teacher is aware of the whole and can bring critical features of the task to the learner which they may otherwise have overlooked. The child needs some concept of the whole, the context in which they are operating but their grasp will be incomplete and this is where the teacher can guide them.



Bliss, Askew and Macrae (1996) describe research into classroom dialogue using video, audio recordings and field notes to identify a taxonomy of 'scaffolding' strategies in three domains, one of them being Mathematics. They use the term, 'assisted performance', which has wider implications than 'scaffolding' and equates in that respect to my term 'supporting learning'. They concluded that in the classroom:

There is practically no joint activity because little use is made of the pupil's contribution...Much school knowledge (concepts such as negative numbers, fractions or conservation of energy) initially exists as part of the teacher's (but not the pupils') knowledge. It is abstract, takes time to communicate and, thus, is hard to scaffold. The effect of trying to scaffold this knowledge turns interaction into a pseudo one, or bypassing, rather than joint negotiation, missing the pupils' input. Further investigation is needed into ways of scaffolding socially constructed knowledge."

(Bliss, Askew and Macrae, 1996, p 58)

This is the key dilemma which I have touched upon a number of times. So much of Mathematics knowledge is socially constructed, as I will discuss in the next section. The learner needs to grasp the socially accepted 'rules' but also needs to make sense of the domain for themselves. 'Assisted performance' possibly implies continuing support where the pupil does not reach the point of 'handover' (Edwards and Mercer 1987) and I have to admit that my pupils did not always reach that point during our discussions. This further stage must be the aim for learning to have fully taken place. I have considered the issue of inducting pupils into areas of socially constructed knowledge, whilst supporting the construction of their own conceptual structures. I have also considered the role of the teacher in stimulating and assisting that process, which is at the heart of learning. However, I have no doubt that it is difficult for a teacher to support, or 'scaffold' the learning of a number of pupils in the classroom, as exemplified in this study working with small groups, but I hope that my

dissertation will provide thought for practitioners as they work through related issues in relation to the domain of Mathematics, to which I now turn.

## Mathematics

The teaching and learning of Mathematics at Key Stage Two is my focus. I offer my model, (Fig 2.1) arrived at during the course of this study, of how I see facets of the domain of Mathematics, natural and socially constructed, relating to each other. I have superimposed on top the operations of teacher and pupil in relation to it. An explanation follows the model.

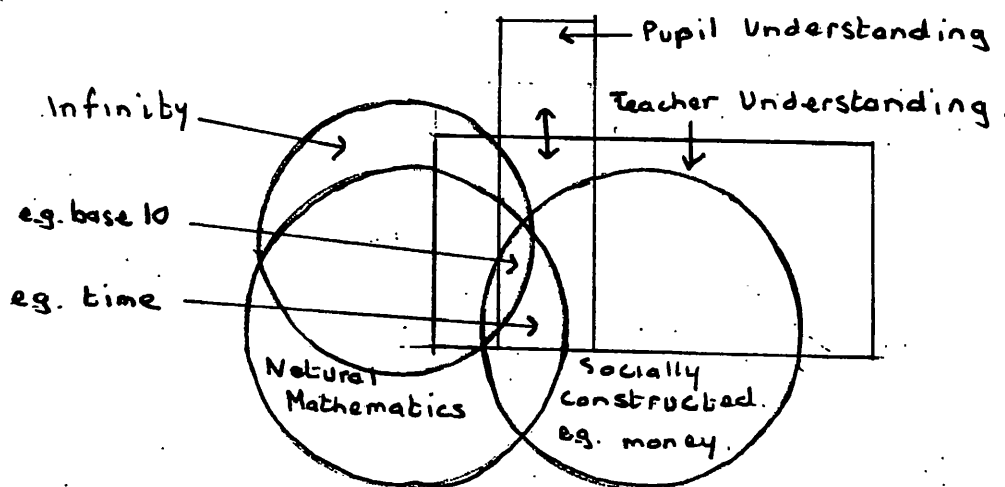


Fig 2.1 A conceptual model of the domain of Mathematics.

I maintain that the aspect of Mathematics which has to do with pattern in the natural world, exists outside any socially constructed framework which we may give it. Others might disagree as follows: "Mathematics is a system of human thought, built on centuries of method and invention" (Chazan and Ball 1999 p 7). Infinity exists and impacts upon the domain, but we only have a partial grasp because our minds are finite.

In my brief discussion of radical constructivism, I argued for the possibility of a stable entity which exists irrespective of each person's perception. I see this entity as encompassing the natural world, much of which is still being investigated by scientists, geologists and many others. Smith (1958)

commented, "It needs only the most casual observation to show the presence of mathematical form in plant life" (p 4). He wrote of the spiral as being one of the greatest cosmic forms and of heavenly bodies obeying physical laws which we express in mathematical language. Spirals can be found in shells and in the arrangement of tiny florets in the heads of sunflowers. It is frequently shown that each unique snowflake has a hexagonal shape, as does each cell in a beehive.

Even if nature, in the behaviour of planets in space and in the form of an insect's dwelling with many examples besides, do follow mathematical principles, it still has to be questioned whether people can assimilate the relationships and complexity of the life forms around them in the same way as others or whether we each hold conceptual understandings unique to ourselves. This is at the heart of radical constructivism. Unless we do grasp the attributes of a hexagon, for example, in a similar way to others, the sharing of discoveries becomes impossible. In fact, no scientist could use the data produced by another; no mathematician could use the calculations of another in order to expand knowledge. We would all have to start from first principles. I believe we can know, at least with a considerable degree of similarity born of identifying attributes, nature's symmetry, its shape and form and that it is possible for the teacher to introduce the learner to what they, themselves, have discovered or had passed on to them.

The mathematical phenomena occurring in nature lead us to a domain where much comes to us as a result of slow construction over a long time, our system of measuring time being just one example. Time, I conceive as being both socially constructed and having an aspect which stands outside human invention. Days, as such, are part of nature, but the division of days into hours, minutes and seconds is a human construct. It seems that a French priest, Gabriel Mouton, "introduced the idea of making the unit of length bear a specified relationship to the circumference of the Earth" (Land 1960 p 23). Thus, an aspect of the metric system was defined. Adjustments to his original suggestion have been enacted since, but the point is made of the relationship between naturally occurring phenomena giving rise to human

construction in the domain of mathematics. Related to this is one central core of the domain, for our society, base ten, a system of arranging ten digits in a given numerical sequence or pattern to signify conservation of number. I maintain it is a construct which children need to grasp in common with other members of their society if they are to operate as numerate participants, but the problem with this construct is its highly symbolic and abstract nature, not least of which is the concept of infinity which it embraces. For example, when one is dealing in decimal fractions with irrational numbers, it is not possible to calculate such a fraction exactly. This calculation, derived from the base ten human design, continues for ever, into infinity. So with other mathematical principles, some a product from both natural and human design, determine how we calculate, how we derive formulae. A simple example is that of the circumference of a circle, approximately three times the diameter, and that would be true of any circle, even one occurring in nature, whether we knew it or not. If we then choose to calculate in decimal fractions, we find ourselves with an irrational number.

Another example of infinity is that of the diagonals of a pentagon which will form another pentagon whose diagonals form another and so on into infinity. We have here a concept which we, as adults, find it hard to comprehend. Children, too, need to begin to grasp the unending nature of decimal fractions, alluded to above, if they are to appreciate in any depth the construction of place value.

If one accepts Piaget and his stages of development, there is little hope of children really grasping the foundations of our society's mathematical system until they have passed the stage of concrete operations because of the need to deal with abstract symbolism and concepts. I do not believe that this is the situation but see the teacher, through language, being able to draw the pupil into their own grasp of the domain which also may enlarge in the process. I think of a time, some years ago, when I asked a child to compare the diameters and circumferences of circles by drawing and measuring. He was seven years old, barely beyond the stage of concrete operations (Wood 1988 p 42), yet we were able to discuss his work and come to an

approximation for pi which he then used to find the approximate circumference of other circles.

The pupils, on the other hand, enlarge the teacher's understanding by their enquiry and insights (White 1992). White conceives of divergent thinking as producing an interaction where the pupil's knowledge enlarges and moves more into the teacher's whilst the teacher's enlarges by contemplating the constructions made by the pupil (p 160). Hence the two-way arrow inserted in the overlapping rectangles which represent the knowledge of the teacher and the pupil. Transfer of knowledge between the two is a process of appropriation (Torrance and Pryor 1998). The sum total of the two participants' knowledge reaches far beyond the domain of Mathematics but also impinges upon it.

In any conversation between teacher and pupil, the teacher may well be adapting their own constructs in the light of rules held by the community and modifying their own thinking in response to the perceptions of the pupil.

By seeking to bring forth and to modify the mathematics  
of children, we are involved in its construction.

(Steffe and Tzur, 1994, p 12)

Our understanding, our mental schema, although grasping fundamental rules, are constantly being revised in the light of experiences and engaging in a discussion is an experience. Cobb (1994) sees two ways in which this might happen. One is 'mutual adaptation', often where shifts of understanding are taking place within the minds of the participants even without their knowing. The other way is one of 'mutual appropriation', in which teacher and pupil absorb and use each other's contributions (Torrance and Pryor 1998). I would hope the latter is the case, each participant growing in understanding and knowledge as they take from each other. The teacher grows in their understanding of the child's view and of the way that child processes thought. For me, during this study, it became apparent that I treated Bill and Jay differently according to my perception of the processes

whereby they assimilate new learning. This should become apparent during part four. The child, hopefully, grows in their understanding of the domain and the rules which govern it. They may also gain a greater insight into the conceptual thinking of the teacher. When I wrote about supporting learning, I referred to calibration given in Cooper and McIntyre (1996 p 118) where they conceive of a process in which teacher and pupil hold each other's understanding in view and adjust to it as necessary. To my mind, this does not imply the appropriation, taking to oneself, the other's insights as an entity, as is thought by Torrance and Pryor (1998), but it does give the idea that the two are adjusting their thinking, absorbing into their own understanding the contribution of the other. It makes the knowledge accessible to the other in such a way that the listener can take what it is they think the speaker is saying and re-interpret it within their own concepts. Such, must be the nature of verbal interaction if knowledge is to be shared.

Having considered the conceptual model with which I presented the reader at the beginning of this section I now turn to concentrate on the task for the teacher, seeking to make the abstract concrete. There are two aspects upon which I wish to concentrate, born out of my reflection on the first conversation I held with Jay (see section 4). Does one use situational settings to explain mathematical concepts (situated cognition), in order to support an understanding and the manipulation of number, or does one focus on the drawing out of relationships in number constructs (the use of pattern in mathematics)? I consider both in the following sections.

### *Situated Cognition*

During my first recorded conversation with Jay, given in some detail at the beginning of section four, I found myself using an example from everyday life to seek to help him to grasp a mathematical calculation. Upon examining the transcript, I asked myself whether this was an appropriate strategy and here I examine the theoretical basis for that question.

Mathematics is a domain with its own language and procedures which may

not relate to the everyday world of the learner because it is highly symbolic in nature. On the other hand, calculations of various kinds do impinge on life. An example would be whilst shopping which even a young child might experience. The task of teachers is to bring symbolism and experience together, but in what relationship? The question has to be asked as to whether Mathematics, at primary level anyway, should always be related to everyday life or whether there is a place for discussing pure mathematical operations. Does a child find it easier to calculate when that calculation is related to their experience of the world, situated cognition, or does this shield them from understanding the symbolic patterning of numerical structures, as in place value, for instance? Meadows (1993) would say this is a problem because symbols are manipulated without referring to their meaning. That may be so, but children must know how to cross-reference, to take calculations and relate them to a variety of meanings so that they operate as numerate members of society. Meadows proceeds to say that a consideration of the meaning of calculations supports consideration of their appropriateness.

Children, acting as mathematicians, need to be able to engage in metacognitive behaviour, reflecting on their work by checking, monitoring and relating to other instances. I call into question whether such flexibility can be acquired when the development of a mathematical concept has been related to a particular set of situated scenarios. Maybe thinking about the meanings in one context might inhibit thinking about them in another. Maybe there are generic concepts and skills, once learnt, which could then be applied in a variety of situations. Cooper (1992) and Cooper and Dunne (2000) question the attempt to use 'real' situations for problem solving, certainly where tests are concerned. The test situations are couched in terms where assumptions have to be made about the 'reality' and the ability of candidates to extract the essential mathematics. Becoming part of that 'reality' in order to extract the features needed can confuse the issue. Extraneous assumptions, about which the student does not have sufficient information, could cause them to work on a premise at variance with that of the examiners'. "The child is required to disconnect their reasoning from

their own knowledge and experience of 'everyday' matters" (Cooper and Dunne 2000 p 100). Previously, Walkerdine (1988) had described this activity as a process of 'de-contextualisation', freeing from one way of thinking and entering another, possibly alien, setting. 'Freeing', therefore, involves suppressing thoughts in one domain in order to adopt them in another. Such is the task of a learner as they seek to operate as a mathematician in a pseudo-real world. Pimm (1995) would concur. He comments:

The connections pupils make in Mathematics, when the teacher may only be aware of the customary mathematical sense of a particular word or phrase, can be fascinating.

(Pimm, 1995, p 4)

This implies that pupils do not always focus on the desired mathematical attributes, desired from the point of view of the teacher and/or examiner, within text book 'real-life' problems. My limited experience in this study shows two children, Karen and Jay, those with more limited mathematical achievement as revealed by their Standard Assessment Test scores (see Appendix 4) took their thinking about the 'problem' into realms which I did not intend when posing the problem. Their thinking was, indeed, fascinating. Bauersfeld (1992 p 471) also draws out the variety in children's conceptions related to paying for tickets on a tram. They had a number of concerns which were not related to solving the mathematical problem but were real in their minds as they projected themselves into the setting described.

The question of vocabulary used within the domain of Mathematics can confuse. A word such as 'difference' has a precise meaning in that setting but in everyday life it can have a variety of meanings depending on the context, a point raised by Rowland (1995). It is very difficult to iron out all the ambiguities and make the problem part of the practical experience of all students.



Resnick (1989), supported by Pimm (1995), said that linguistic interpretation added complexity to story problems. Why should this be so? Children become engaged in comprehending the text. They may not understand all the vocabulary or the way the sentences are constructed, even if they are verbal. This is problem to solve even before accessing the mathematics. In my findings, given in section four, I give the example of children discussing the mathematics needed to calculate entry into the Kennedy Space Center. This is before they engaged with any calculation. Their decision on which operation to use was discussed in relation to how easily the calculation worked out, not a comprehension of the question. Their past experience of such questions in textbooks which are “massaged for the audience” was quite a sensible premise upon which to work when all else failed. It may be one thing to require children to identify the sum they need to undertake, once they know how to perform the calculation, but actually learning how to do it whilst grappling with a comprehension problem adds complexity to the task.

Murphy and McCormick (1997) make a comment in relation to Science and Technology teaching which is also true of Mathematics, “problems have to be personally meaningful and purposeful within a social framework” (p 463). Calculation within an actual situation in order to solve a presented problem can be said to be ‘authentic’, providing the necessary context for shaping thought. Participants in a scenario, such as the purchasing and using of ingredients in cooking, can perform far more complex tasks, within a hierarchy of difficulty, than they can when presented with a similar problem on paper outside the context (Carraher, Carraher and Schliemann, 1985; Cooper and Dunne 2000). I believe this to be because the question of comprehension is removed, the need to project oneself outside the concrete here and now is overcome. The purpose of the calculation is clear.

Resnick (1989) saw the need for children to be able to develop their own understanding and methods of calculation, a point emphasised in the National Numeracy Strategy (DfEE 1999a), and then to be able to map the arithmetical operation onto a problem in order to solve it. It is a necessary

skill, but understanding of the operation is needed first. I would add that the skill of mapping the operation onto a problem also needs to be taught. The children need to know how to extract the essential mathematics, and this might not be immediately obvious. Walkerdine (1988) quoted two examples of seeking to make mathematics comprehensible to small children by the use of coins in small quantities (pp 140-143). I am not sure she was advocating the approach by quoting these extracts of discourse because the children brought in extraneous matters to the conversation which might negate her point. However, the children do appear to make responses which would indicate understanding, but I question whether this is a case of the adult hearing what they wish to hear. Walkerdine went on to point out that the amount of coins used for the 'shopping' made it unlike the real thing and that the coins were returned after the 'purchase'. The practical setting, she maintained, could be "misleading and downright unhelpful" (p 146). This is the point I will draw out from my own research in section four.

Not all would agree that the pure mathematics comes first. Meadows (1993) considers that it is the very symbolic nature of number disengaged from everyday reality which hinders children from understanding how to manipulate the numbers so as to reach an expected solution. She would probably advocate the setting of the calculation of algorithms into problems which are within the experience of children so that they can follow what is happening to the numbers. Her view would be supported by various people, for instance Ainsworth, Wood and O'Malley (1998) who justify using representations of small coins for their research into children's development of computational ability by reference to the work of others but do not examine the issue in detail. They emphasise, "the importance of allowing children's concrete and everyday knowledge to support the learning of other types of understanding such as principled and computational knowledge" (p 142). Their work does not prove or disprove the superiority of using the concrete and everyday knowledge because pre- and post- tests, as well as the learning in between all use the coin representations. Answering the question of the appropriateness of using such a context for the children's work, is not their purpose.

Particularly for those holding to Piaget's view of a concrete stage of thinking preceding abstract thought, the need to present material in what could be called 'situated cognition' is strong. von Glasersfeld (1994) holds that a string of mathematical symbols remain meaningless for the learner until they have engaged in activities such as counting and have had a sensory motor experience on which to base their mental operations. I would agree with that. Counting objects, I maintain, is an authentic activity, not a contrived one. Jaramillo (1996) also advocates that "students learn concepts by using manipulatives (concrete objects) in a realistic-authentic context to construct meaning from their interpretative experiences ... learning how to associate these tangible objects with abstract-mathematical concepts" (p 137). Further discussion of manipulatives appears later in this section. I have no argument with 'authentic' experience, if this is what is advocated, but it is not always possible to provide it for all learning situations. It is when reality is contrived for the purpose of teaching mathematical concepts, that I believe problems are created for children.

Bruner (1971) saw three stages of development; enactive, when one needs to work with actual objects; iconic, when one can manipulate objects mentally, thinking in pictures; symbolic, where one can manipulate symbols in the abstract. Sometimes children become confused when we seek to use a context to help them understand a mathematical concept. Perhaps it is the very need to move from one stage to another within a single session which confuses. My experience during this study (see Karen 12.5.98, talking about the Sea Life Centre, and Jay in Bill and Jay 17.5.99 talking about a birthday on February 29th on pages 134-7), was that asking questions in the context of their experience shifted their focus from the computation to the actual situation. They were thinking in pictures but could not move away to the symbolic.

The introduction of a familiar setting led Jay and Karen off at a tangent. There might also be another reason why the use of actual situations

confused them. Perhaps the issue was the way I used the problems, and that led to thought away from my agenda. Perhaps there are more fundamental reasons why children can find such settings unhelpful. I believe there are, and that one has something to do with infinity. The manipulation of numerals allows for such a concept. Finite everyday situations which are used to give a context for the understanding of Mathematics limit the learner's understanding of the continuing nature of some symbolic operations. I pick up the importance of pattern in Mathematics in the next section. Often pattern has a repeating, never-ending quality which is lost in a life context.

More important, probably, than the subject of infinity is the fact that everyday illustrations have aspects which work at cross purposes with pure mathematical thinking. For instance, Ainsworth, Wood and O'Malley (1998) wrote of using the manipulation of money as the basis to enhance conceptual thinking in calculation, as I have already indicated. When I was a teacher in school I was tempted to use money, fractions of a pound, to support an understanding of decimals and have witnessed others using a similar approach. We often see an amount written as £8.56, the pennies expressed as one hundredth of a pound. We have an amount expressed to two decimal places. However, in school, we are wanting children to understand the first decimal place as one tenth of a unit, the second as one tenth of a tenth. Children need to understand decimals as an extension of place value where an identical digit to the right of another represents one tenth of its quantity (Pimm 1995). The concept of one hundred pennies in a pound is strong and not many of us have such a clear concept of ten pences so we do not see the first decimal place in money in this light. This becomes a small but, I would hold, significant inhibiting factor to the understanding of decimals through money. My view is that children should understand the pattern of pure number first and then immediately be introduced to its relevance for common situations. Granted, children do not bring to school a total ignorance of using money but, as I have just discussed, their experience can mislead or divert their thinking.

The use of calculations involving money was also used as an example by Brown, Collins and Duguid (1989) to illustrate the use of multiplication. Their argument was that students learn algorithms and routines out of any context and are not be able to apply them in a particular situational setting. On the surface, this seems to contradict my argument above, but in fact there is little disagreement in our positions. I am not arguing for the rote learning of routines totally outside the understanding of how algorithms are built. The context for the acquisition of mathematical understanding is that of pattern in number. I consider it to be authentic, in fact the key set of domain-specific concepts to be necessarily acquired. This understanding is the tool, referred to by Brown *et al.* (1989), which can then be given a context of activities for any community using the tool, for instance the worlds of trading and construction. It is this quest for pattern in number that they portray as domain specific behaviour in teaching problem solving, that of collaborative work on a magic square, very similar to some of the activities I introduced to my pupils during discussions recorded for this study. I do not argue for the acquisition of this 'tool' as an end in itself, but as a means by which it can be used flexibly in the situations of life.

Miles and Miles (1992) say that children do not always make the connection between concrete manipulatives and abstract number. This is true in their experience even for apparatus specifically designed to give an understanding of base ten. E von Glasersfeld (1994) also states that sensory motor material cannot convey to the pupil mathematical operations ready made. They need the intervention of a teacher. Pimm (1995) advocates the use of manipulatives but also adds certain caveats, "with suitable teacher guidance," (p 22), adding "Physical manipulation alone is seldom enough: teachers also encourage pupils to talk about what they are doing," (p 27). Why is it that the use of manipulatives, such as Dienes blocks, with their clear base-ten properties, do not convey the teacher required concepts when children handle them? Pimm says that the child's attention is drawn away from the intended mathematics and onto the need to control the apparatus. It adds a dimension of complexity to the task, in the same way that dealing with computational problems set in pseudo real-life situations adds

difficulty. This is not to say that the manipulative is of no value. It can be, as Pimm (1995) says:

- \* a means of illustrating something mathematical;
- \* a concrete representation of an abstract concept;
- \* a tangible means of generating and exploring mathematical ideas.

(Pimm, 1995, p 25)

The exploration needs the input of the more knowledgeable adult who can hold the manipulation and the concept in balance, supporting the child as they use one to illumine the other. The adult can help the child see the relationship, to grasp the concept which is wider than the apparatus and to move to a point of independence from it. I did not use apparatus during my conversations with the children but I did make use of drawn models which, whilst they could be held to be abstract representations, I view as having a similar value, used in the way outlined above.

In her survey, Hunter (1994) found that a number such as 28 was thought of by many children as twenty-eight single objects and not as two tens and eight units. Without a sound understanding that the position of a digit determines its value, learners find their grasp of place value and related matters to be tenuous. They also find calculations and algorithms mystifying. I return to Pimm (1995) who says that there are two separate aspects to algorithms, 'what to do' and 'why this is what we do' (p 69). Children can be taught what to do without understanding the implications of placing digits but when they forget what to do they are left without a strategy, unable to use their understanding of why we do it to resurrect the lost learning. In addition they have difficulty transferring to a new situation. Bereiter (2001) says that whoever consciously seeks to make connections between concrete and symbolic operations can make the transfer (p 77). They ask the question, why are we doing it like this? The understanding is crucial.

Children need to be able to engage in metacognitive behaviour to be able to check, refer, cross-reference, evaluate and use alternative strategies (Meadows 1993), but to do this they need to know how the symbols relate to each other. Such metacognitive activity comes through language and is necessary for concept formation (Vygotsky 1962). The difference between viewing learning Mathematics as a constructivist activity, understanding the way mathematical symbols relate to each other, and one which is sociocultural, based solely within a cultural setting (Cobb 1994) would lead to just this distinction. If one holds that children need to understand the manipulation of number, for instance, as ordering with the intention of seeing relationships and pattern the emphasis is less likely to be on seeing the relationship of calculation to operating as a numerate person within the culture. Cobb argues that both are involved, but one needs to lead the other, and this relationship to be drawn out through discussion. As has been presented above, a grasp of how the symbols within the domain of Mathematics are manipulated to form patterns is, to my mind, the priority. Transfer to use within a situation can then follow.

### *Patterns within Mathematics*

Whether Mathematics is to be viewed as a “body of knowledge or as a way of thinking” (The Open University 1990 p 57) is important for my pedagogy. As a constructivist, I would view it as a way of thinking and my study emphasises the understanding of the domain. Understanding implies solving the problem of, ‘why things are done this way’, of seeing within the domain of Mathematics, and number in particular, how one aspect relates to another. Relationships in this context can best be seen as patterns. In order to grasp the ever increasing complexity of the patterns, changes in the concepts held by the learner need to take place. Mathematics as problem solving implies ‘conceptual change’ (The Open University 1990 p 57), and this is what I am about because I believe that children need to grasp the inherent nature of Mathematics as one of pattern. I am not alone in this view:

Mathematics educators have long recommended  
exploiting patterns and relations and encouraging the use

of informal reasoning (thinking) strategies as ways of facilitating the mastery of number combinations,

(Baroody, 1999, p 171)

and this bears out the earlier words of Land:

The interest in counting shown by these young children seems to lie in the numbers themselves, in repetition and in the patterns of the numbers, rather than in actually counting things.

(Land, 1960, p 1)

Numbers relate to each other in a network of structures which needs to be grasped. Form and formulae depend on human appreciation of their symmetry. Ainsworth *et al.* (1998) would claim that this is best achieved by experimenting, hypothesis testing and the active seeking of solutions to mathematical puzzles, but also say that primary pupils do not readily engage in the active seeking of multiple answers. I hold that their reluctance to do so needs to be overcome because that reluctance would detract from their appreciation of the pattern of number, an aspect of which, place-value, or more accurately 'quantity value' as Thompson (1999) would say, is vital to an adequate grasp of the manipulation of numerical symbols.

Unless children are able to embrace a series of strategies for calculation there is a danger that they will follow a rote learned procedure without bothering to understand the underlying logic. This, of course, limits the ability of transfer to new situations. It can lead to systematic mathematical thinking but wrongly applied. Askew and Brown (1997) advocate spending a great deal of time helping children to calculate mentally and to delay the use of traditional algorithms until much later than has hitherto been the practice. By doing this, they feel children are encouraged to see connections, understand patterns and then to use them to solve problems.

Pupils need to be given opportunities to develop flexible methods of working with numbers, including mentally,



and to develop mental methods that enable them to use known facts to derive facts that they cannot recall.

(Askew and Brown, 1997, p 13)

The pure memorisation of facts such as multiplication tables is uneconomical and hazardous, claimed Whittaker (1986). I would not totally agree. So long as the pattern for producing the tables is understood, the ability to recall certain facts at will, rather than having to work them out every time, can save a great deal of effort. Some facts need to be known so that others can be derived from them.

Unless a teacher understands the need for pupils to have a clear grasp of pattern in number and the ability to manipulate known facts to derive others and to solve problems, the teacher's responses to perceived understanding may not be as skilful as it should be. This is why I spent so long on place value and the structure of number in my discussions with pupils such as Jay, Gemma and Hayley, but I was fairly sure that even after our work their concepts had areas of confusion. How can these confusions be alleviated? This is where a teacher's skill must operate within the child's conceptual understanding which Vygotsky called their Zone of Proximal Development. Whether a teacher can define the zone for any particular child or not is worthy of consideration but beyond the scope of this study. What is important is that the teacher must be able to make an accurate formative assessment of the child's developing understanding of number relationships and operate at, as well as forward from, the point of need. The accurate assessment may well be more than just appreciating what has been written on paper or, even, spoken in answer to a question. It probably involves listening carefully to how the child expresses their thinking; the way they form their argument; the way they move in their thinking from one premise to the next; the way they appreciate increasing complexity of pattern. I have to confess that analysis of my discourse with pupils showed that often I was not accurate in my assessment of their understanding and faltering in the support I gave. For further discussion see part four, particularly the section on discourse.

Askew and Brown (1997) talk about using the known to derive the unknown and this is precisely how the teacher can support a learner as they develop understanding. Although difficult, Ainsworth *et al.* (1998) claim it should be possible to determine many of the mathematical facts known, and number patterns appreciated by the learners, before using these to help them find ways for themselves of constructing flexible pathways to new solutions. Chazan and Ball (1999) give the example of teachers holding back as students discuss, but then contributing 'substantive mathematical comment' at appropriate moments.

We hold this to be a kind of "telling", a providing of intellectual resources, a steering, an offering of something intended both to contribute to and to shape the discussion.

(Chazan and Ball, 1999, p 9)

The skill is to set the problems requiring solutions at the appropriate level and then to present the learners with stepping stones which take them in a forward direction. Steps are linear but stepping stones may be set in such a way that the learner can elect to use them or not, taking a variety of pathways or using flexible strategies. This I tried to do by presenting material such as the two squares where children could discover relationships and pattern and where I could listen for opportunities to take thinking further.

Kamii and Livingston (1994) take an extreme constructivist view of acquiring mathematical understanding by agreeing that children can learn from others, but holding that the result is a construct of their own making. Each person has their own understanding which is unique. Children would be encouraged to interact with numerical relationships and their social environment by the answering of questions from the teacher, but should not be told what to do because that would be the construct of another person. I do not agree that questions are the only stepping stones available to support or help the learner make their own constructs or that there is never a place for passing on some factual knowledge. So long as the knowledge can be

accommodated into existing schemata the pupil can adjust and use that information. A teacher encouraging exploration of an idea by introducing their own hypotheses into the conversation might also provide valuable support in promoting flexible thinking.

Bruner (1971) suggested that it is not always necessary to encourage free exploration of concepts when he quoted the work of Dienes in presenting pupils with a highly structured set of cards through which they worked to a high level of abstract mathematical thought. However, these children were said to have IQs of 120-130. Whether one agrees with the idea of equating intelligence with being able to perform on particular types of tests, the fact remains that these tests favour mathematically inclined abstract thought which would be receptive to that kind of approach. No wonder those particular children did well. One has to ask whether the experiment displayed a typical response, making connections, accommodating to newly appreciated relationships. The discussion thus far has emphasised flexible thinking, not working through a set of highly structured paths because children need “time to discover the regularity themselves” (Baroody 1999 p 170). When they are encouraged to look for pattern they are making sense in their own terms, for example when Bill and Jay discussed a pattern they had discovered (19.4.99 on page 157).

Key issues for the teaching of Mathematics which arose during my research centred around:

- \* the induction of learners into socially accepted ‘rules’ in such a way they become their own;
- \* the role of situations, both fictitious and authentic in enhancing understanding;
- \* the encouragement of an understanding of pattern in Mathematics in order to facilitate application to problem solving.

My research question highlights oral exchange as a vehicle for addressing these issues and it is to a consideration of how best to engage in such oral exchanges for the enhancement of learning that I now turn.

## **Aspects of discourse**

Within this section, I examine how others have approached the task of analysing discourse in order to give a context for my own attempts. I continue by looking at some strategies employed by teachers which have resonance with my own approaches to discussion with children. The term, 'discourse' can be given as, "the communication of thought by speech: mutual intercourse of language. ... a conversation" (The Oxford English Dictionary 1989), which, likewise, can be defined as, "verbal communication, talk" (Collins English Dictionary 1991). The same dictionary continues to define discourse as, "a unit of text used by linguists for the analysis of linguistic phenomena that range over more than one sentence". This is the sense in which I have tended to use the word in this dissertation. The word, 'discussion' is generally viewed as a development of a conversation: "an argument or debate with a view to elicit truth or establish a point" (The Oxford English Dictionary 1989), whereas a conversation can be given as an "informal talk between people, communication" (Chambers 21st Century Dictionary 1996). However, the Collins English Dictionary also gives the verb "to discuss" as "to have a conversation about". I aspired to a discussion when talking with the children for this study but sometimes we were engaged in purely communicating our thoughts, undertaking a conversation. It is difficult to determine when the one becomes the other and, because dictionaries use the words interchangeably and it is not a central issue of this dissertation, I have used them in a similar manner.

Edwards and Mercer have written:

The overriding impression from our studies is that class room discourse functions to establish joint understandings between teacher and pupils, shared frames of reference and conception, in which the basic process (including the problematical features of that process) is one of introducing pupils into the conceptual world of the teacher and, through her, of the educational community.

(Edwards and Mercer, 1987, p 157)

As discussed earlier, in the section on radical constructivism, I would disagree that the function of the basic process of classroom discourse is that of introducing pupils to the conceptual world of the teacher, even the educational community. Whilst there is a need for the child to embrace concepts common in society, within that 'common knowledge', they need to develop their own frames of reference. Beyond this, one has to consider whether joint understandings are established just because verbal interaction is taking place between teacher and pupil. If the teacher uses concepts, vocabulary or syntax which are totally outside the understanding of the child they will not communicate. My study builds on the work of others, some of which are cited below, who have sought to investigate the nature of discourse in the classroom and how teachers and pupils establish joint frames of reference.

In a study carried out in Leeds, Alexander, Willcocks and Nelson (1996) used tape recordings to analyse discourse for structure, syntax, pedagogical strategies, curriculum content and number of children in a discussion group in order to study changes in the curriculum associated with discourse and pedagogy. In the conclusion of their report they state that what really matters are pupil outcomes which are consistent with the learning goals being pursued. I agree, and outcome, pupil learning, is at the heart of my research question. However, what is learned is an important consideration. If, whilst learning to compute using a certain algorithm, the pupil is left not understanding why that algorithm produces a correct result, all they have learnt is a series of actions which, if forgotten, leave them without that ability to function. The process by which the learning is achieved, therefore, is a vital part of that consideration. If the children learn that calculation through the construction of understanding which allows them to transfer their learning to a new situation, they can be said to have their own conceptual framework upon which to draw. Bereiter (2001) draws out the difference between the child who has learnt how to undertake a task and one who has taken time to understand the task in his or her own terms, thus making it possible to draw on that understanding for transfer to new situations. The latter thrives, the former struggles to embrace new learning.

The process is important because those conceptual frameworks become increasingly complex as children respond to external stimuli. If the nature of the stimuli is inappropriate to the learners' needs, misconceptions can be built in their minds. The process of delivering the stimuli, therefore, is important and within this study I concentrate particularly on the process of delivering oral stimuli.

Whatever the process, Alexander *et al.* (1996) go on to say that evaluating products is problematic because it is difficult to find outcome measures which are valid and consistent with learning goals, whatever they may be, and in my case the acquisition of socially agreed mathematical concepts, as discussed earlier. Outcomes are part of a developmental process and may well alter as soon as one seeks to assess or evaluate them. In the oral process, the evaluator, or teacher, has to listen to what is said by the pupil; how it is said; even what is not said in order to establish pupil understanding.

The question now has to be asked, "how do you study the development of concepts within the learner?" One approach is by analysing the discussions which take place in the classroom. Within a normal classroom, the teacher has to follow the development of their discussions with pupils as it happens with little time to reflect. It is possible to record and even transcribe the conversation but even this does not guarantee an accurate assessment of how concepts are changing or developing. It does, however, afford the opportunity for the teacher or researcher to identify moments when the speaker seems to be articulating a development in their understanding. By tracing the utterances about a particular concept over time it should be possible to see a developing complexity of conceptual thought on the part of the learner. I confess to not having seen much development as I examined the discourse from my discussions with the children. One possible example, Gemma 19.5.98, 9.11.98, 8.3.99 is given on pages 94, 102-3 and 113, but this is over a period of time and certainly cannot be attributed to my inputs alone. Probably any one concept made too rare an appearance in the transcripts for developing complexity to be apparent. The question, of how

to trace developing complexity in understanding, needs further consideration, not possible within the confines of this study.

I wrote above that it was important to consider how things were said. I continue by saying that how the points made are received, listened to, is of vital importance if children are to avoid misconceptions in terms of societal expectations. The listening is the responsibility of both parties in a conversation. Without that listening, it is not easy for the teacher to respond appropriately to needs of pupils. As Jay and I spoke during our initial conversation I found myself using several oral strategies as vehicles for conveying and eliciting meaning. I sought to examine how appropriate they might have been in listening and responding to the concerns of Jay. These were then used as a stimulus for examining how one might use oral strategies. In the course of that examination a further strategy, supposition, was identified and noted for consideration. In all, listening became the dominant theme. Whether the listening is to learners or to peers, the need to engage in active listening is the same. As Riches (1997) points out, "although we hear a voice, the words are not listened to and the mind is not engaged" (p 174). He goes on to say;

Real listening is active in the sense that what is said is taken in, thoughtfully considered and, if relevant, shapes future exchanges. ... Active listening requires getting inside the sender's point of view.

(Riches, 1997, p 175)

When teachers are teaching, it is easy for them to be thinking about what they want to teach, what the next point should be, that is, working to their own agenda. Too often, the teacher does not consider the child's input thoughtfully enough. In that case, the child's point of view is only partially grasped and future inputs from the teacher are not shaped by the pupil's thoughts. The pupil's concept should be changed at the point of need, best identified by an accurate evaluation of their input.

Adult responses to pupil input can take the form of a variety of discussion

strategies and it is to those identified as a result of analysing the transcript of my initial conversation with Jay, that I now turn.

*Listening as part of Initiation, Response, Feedback (IRF)*

Sinclair and Coulthard (1975) developed a very detailed system of analysis which, they claim that with minor modifications, can be used to analyse a wide range of classroom situations. I find this disturbing because there appeared to be a rigidity in the exchanges they analysed which seemed to me in most instances to take the form of IRF, that is, initiation, response and feedback. By this statement I register a concern that IRF may not be the most successful strategy in encouraging concept formation. Sinclair and Coulthard, themselves, came to the conclusion that not all well-prepared lessons, given in this form, bring about successful learning and that this could be because pupils rarely challenge the teacher's orientation. The teacher always has the last word, whether pupils really understand or not. If pupils do not understand, their learning of what the teacher intends is minimal.

Alexander (1997) argues that there is a place for such structured conversations because questions help the teacher to find out what a child knows and giving feedback helps the child to monitor their progress. That may be so but surely it depends on the nature of the questions as to whether they elicit a response which is valid in terms of the pupil's true understanding and whether the feedback is understood by the pupil in the way the teacher intended. I consider the nature of open ended questioning in particular in the section following this and also examine the effect of pupils' reception of questioning. Some years ago, Barnes (1976) maintained that so often pupils interpret a question as the opportunity to show the teacher that they can give the right answer. The pupil assumes the teacher knows the answer and, therefore, as Barnes says, the teacher is a poor audience. They are not perceived as those who have a genuine interest in the explorations of the child, in really wanting to know the child's thoughts about the subject. Questions go wrong because the teacher fails to project into the pupil's viewpoint and assumes an answer, based on the pupil's ability to guess what



the teacher wants. More than one “why?” in my work following a correct answer from the child elicited the response, “I don’t know.” The child had been able to read into the context what they should say but were not sure of the reason for that answer. If there is a place for IRF we need to know how and when, as well as what other types of exchanges are possible.

IRF, I believe, has a role to play in enhancing learning and we need to find times when the strategy can usefully be employed. One example I give from my work was when I wanted Jay to focus on an inaccuracy in his work (pp 95-9). A non-specific question, ‘can you see the difference?’ left him guessing which difference was in my mind. He had no criteria by which to judge the appropriateness of his response because he could not appreciate where his work was amiss. I gave him no clues. He had to interpret my intention and guess. Later, my questions became more closed, asking for specific factual answers and giving specific directions. The moves, building on one another, led him to the point of error realisation. This, I believe, to be an example of how an IRF sequence supported the clarifying of a misconception, just one way in which it could profitably be used. However, the profit is with the situation and in many instances IRF may not be the most useful approach. As Barnes (1976) said, ‘the more a learner controls his own language strategies and the more he is enabled to think aloud, the more he can take responsibility for formulating exploratory hypotheses and evaluating them’ (p 29). I add, the more the learner is constructing their own understanding rather than just entering into the teacher’s, the more he or she learns.

Flanders (1970) argued that IRF interchanges occurred more frequently in Mathematics, compared to other domains. He also found that in his research teacher initiation was higher in classes where the ability of the students was more limited. This may be because they take time and teachers are unwilling to see the distress as children try to make sense of a mass of data. I certainly have felt this, but that might be because I have not ensured a secure base of understanding within a child before presenting him or her with an inappropriate degree of uncertainty. (See Jay 22.2.98 pp 2-5.) The need is

even greater with less-able students to give them space to understand at their own pace than for their more able counterparts who are more likely to follow the teacher's reasoning. Whatever is the case, teachers need to ensure that they have considered the appropriateness, the context of and the reason for all the questions they ask. They need to consider whether the child has the relevant understanding upon which to draw for their answer; whether the jump in understanding required to answer is sufficiently small as to allow the child to assimilate it into their schemata and whether they provide feedback which aids that process. They need to consider whether the subject is part of a socially produced concept to which pupils need to be inducted or whether it allows for individual interpretation.

So far I have referred to IRF, but Barnes (1976) distinguished feedback as being of two kinds, assessment and/or reply. If the teacher stresses assessment, the pupils will strive for an acceptable performance, whether they understand or not. In a reply, there is a building on the response which can help the pupil restructure. I would liken this difference to the one which could be drawn between IRF and IRE (evaluation) the term used by Cazden (1988). If the teacher purely provides the learner with an evaluation of their performance, the learner only has the possibility of constructing understanding up to the point of their response. If the pupil is provided with feedback, or a reply in which the teacher builds on what they have said there is the possibility of them understanding more. Eisner (1991) writes, "Using contingency questioning [rather than evaluation questioning], the teacher makes adjustments to support student thinking and expression of ideas, stretching them beyond where they are to the next higher level of functioning" (p 136). Can that be true of feedback following response to a closed question, the type of question often used during an IRF sequence? I think so because it is specifically related to a response the pupil has just made so it is likely to have a direct link with existing schemata.

Jay commented on pure evaluation and the experience of receiving feedback by saying:

When we do it in class, write it down that we've tried to

work it out, give it to the teacher and either he marks it right or wrong, but with this we sort of just ask, we work on one question for a long time so you can think about it, so then in the end we come to the right answer straight away.

(Jay and Bill, 24.5.99, p 18)

Feedback could be seen as a means whereby the pupil can monitor their progress in understanding and, where necessary, realise the need to adjust their thinking, even though Edwards and Mercer (1987) hold that whatever is said after a pupil responds the pupil will interpret as evaluative. I am not sure that matters. Where a teacher-pupil relationship is one of mutual respect, the pupil can welcome and use the evaluation linked to feedback, even if it is negative.

As I indicate, I would not want to rule out IRF approaches to the development of understanding, because if the teacher and pupil share a basic point of reference the teacher can ask questions in such a way that each one is a small development on the previous one and the pupil, who is following these increments, will be helped to grasp the whole. How are teachers to check whether the pupil is sharing the understanding if they do not ask? It is all very well saying that learners should be constructing their own understanding but they need support, presented in manageable amounts, with which to carry out the construction of emerging concepts.

Where pupils break out of the pattern of IRF and produce divergent answers with real learning potential, as Alexander (1995) sees it, the interjections are not always followed up by teachers, according to his findings. How might a teacher respond? I return to Flanders (1970) for a number of possible responses:

by acknowledgement or paraphrase, by making comparisons to authoritative sources or task requirements,

and by comparing the ideas expressed by one pupil to those of another, or something the same pupil said earlier.

(Flanders, 1970, p 253)

These are not new ideas but are still most useful points for consideration. I found in my work at least two instances where I responded to children in such a way. When a child said that he was really stuck, I referred him back to earlier work and it was not long before he saw the relevance of it to the new situation and was able to work through it (Bill 5.5.98 p 11 - see pages 95-6). On one occasion, we were seeking to solve a question about the number of fish in a tank at the Sea Life Centre when the child asked a question about how the centre obtained their fish (Karen 12.5.98 p 4 - see page 137). I explained about breeding. It certainly did not help us with the mathematics under discussion, but she may have added to her understanding of the world as I sought to answer a question relevant to her thinking, rather than ignoring it. Such a response would not have been so easy to give in a classroom setting where the discussion might have been irrelevant to other pupils, but in the one to one I could acknowledge Karen's concerns.

### *Listening in order to formulate open-ended questions*

So how does the teacher stimulate the kind of pupil-initiated responses to learning where that pupil is free to make contributions relevant to their own thinking, yet still within the designated area of knowledge? One approach is by asking open-ended questions, questions which encourage children to produce their own individual responses and implicitly demonstrate that there are alternative ways of dealing with the question, each equally appropriate and helpful. There is no one right way to respond. Wright (1990) advocated reasoning questions which encourage children to hypothesise and use mathematical vocabulary as a natural part of their work. That may be fine but how do children cope with such questions and how do teachers ask those appropriate to the situation? It has been my experience that pupils can find such questions as 'how?' or 'why?' threatening when faced with a mathematical problem and it takes considerable skill on the part of the teacher to know when the pupil has a) sufficient understanding b) sufficient

confidence to cope with such a question and c) when they need challenge or support.

Whatever response a child may have ... has to be challenged and deepened, but in ways which are an empathetic response to that individual.

(Bonnett, 1994, p 170)

Much will depend on their past experiences, whether the culture of their classrooms has been conducive to independent thought and exploration of ideas or not.

Pollard and Tann (1993) give a taxonomy of questioning, including questions they describe as having high level cognitive demand, and classify them according to purpose:

- \* to explore information and ideas ...  
reasoning/interpreting, hypothesising/speculating,  
imagining/inventing;
- \* to encourage synthesis of information and ideas by  
focusing on contradictions, discrepancies, different  
sources of evidence;
- \* to encourage evaluations, decision-making and  
judgements;
- \* to encourage the transfer of ideas and application of  
knowledge.

(Pollard and Tann, 1993, p 229)

I believe they are saying that the teacher should so phrase questions that pupils are stimulated to undertake the kind of activities outlined above. Certainly the emphasis encouraged in the Numeracy Strategy is questioning of the kind advocated by Pollard and Tann with examples such as, "Could there be a quicker way of doing this? Would it work with different numbers?" (DfEE 1999a p 6). Johnson and Gott (1996) give an example of the difference between two questions about condensation. The first, "Where

has the water come from?" is closed and assumes children know that water has a source. Better, they say, a question, "How come water is now here?" This open question does not assume conceptual knowledge on the part of the child and their answer would have been stimulated by their construction of understanding. I have come to the conclusion that when open questions are appropriate to the understanding of the children they can be used both to challenge thinking and support in the development of understanding. How far depends on the skill with which those questions were employed, and it is there that I detect considerable room for improvement in my own work.

I wrote earlier of the need for a teacher to listen actively. Bonnett (1994) sets this into the context of teacher/pupil interaction:

facilitating learning requires the teacher to 'listen' for what is incipiently there in the consciousness of the pupil: the questions and possibilities that his or her present thinking inherently hold within itself - and to challenge him or her to acknowledge and pursue them. To do this the teacher must also 'listen' to what things themselves (including, of course, human culture and its artefacts) have to offer so that she can put the pupil in the way of new experiences which may contribute to a deeper and broader understanding.

(Bonnett, 1994, p 180)

The question, "How come water is now here?", given above, might well provoke a response which has aspects of present commonly held scientific theories about condensation, but some misconceptions as well. First of all, teachers need to know what the theory is in some detail, to have 'listened' to it so that they have a grasp of its complexity and the inter-relationship of attributes. They, then, need to tease out from the child's point of view those attributes which align before formulating questions arising from the points of agreement and difference.

The challenge would be to avoid telling, or asking closed questions in order

to direct thinking in a certain way, taking the teacher's agenda, and to devise further open questions which provoke exploration and development in thinking about condensation. "How do you know?" might be a possibility, or, "Why do you think that?" Both cause a focus on an aspect of the answer which could then be explored. Bonnet calls such an approach, 'person-centred', because the focus is on the learner's ideas and not on the subject matter. He goes on to advise that the teacher should also offer something of their own understanding but only in relation to that of the learner. Knowing when and how to do that, moving from the stimulating of comment from the pupil to inputting new thought; knowing how to combine approaches so that the focus is on developing the skills given by Pollard and Tann is demanding much of the more knowledgeable adult and an ideal of which I fall well short in my discussions with children.

*Using 'wait time' to listen a) to the other person, b) to yourself*

"Silence appears as a rich communicative resource," write Jawonski and Sachdev (1998 p 273) in their study of secondary school pupils' beliefs about the use of silence. One of the problems with encouraging reasoned responses seems to be that after asking an open question teachers do not give sufficient time to allowing pupils to formulate their answer. Having analysed over one thousand two hundred tape recordings, Rowe (1974) concluded that a wait time of between three to five seconds resulted in the quality of interactions between pupils and teachers being enhanced on eight counts. What she did not explore was whether the pupils' learning was actually increased. All she claimed was that "changes in wait time shift the game towards a more equitable state" (p 203). It might not have been possible for her to have examined this aspect, given the context in which she worked and the inexact nature of learning, but it is an important consideration. Tobin (1986) did consider student achievement and concluded that the "mean summative achievement for the wait time feedback group classes was higher than mean summative achievement for control group classes" (p 196). So, where the teacher was encouraged to wait, by frequent feedback, achievement seemed higher, but I am not sure how the study controlled the underlying cognitive ability of the students.

Whilst their progress was measured in the same way the rate of their ability to assimilate new material was not. For some, their ability to learn may have been greater than for others. Was it the underlying abilities of the children or the skill of the teacher in employing silence which determined the greater progress in the feedback class? This needs further investigation. Cazden (1988) said that a change of intent is not enough, the teacher needs to pause for more than a second in order to give the child time to think. Wood (1992) contended that it was not so much the level of question that helps pupils but what happens afterwards. The longer the silence, the more profound the response from the pupils. Even after these comments had been in the public domain for some years, Pollard and Tann (1993) found that the average wait was still only about two seconds (p 230). This is a matter of concern because if the quality of pupil contributions, or as Rowe (1974) puts it, "the value of eight student outcome variables" (p 204), is greater when the teacher waits more than three seconds than it is when they wait less time, the likelihood is that pupils are engaging with the content at greater depth. They are given the space to assimilate the context of the question or information they have just heard, to seek for related knowledge in their understanding and to evaluate how the two relate to each other. The opportunity to build on the other's contribution to the conversation is enhanced. Rowe makes reference to the fact that without pauses conversations tend to be fragmented, speakers contributing but not listening with adequate attention to others, so that their contributions run in parallel, rather than building on those of others.

Children using space to process their thinking takes time, possibly less for the more-able student than for the one who does not learn so rapidly.

For teacher discourse to influence student learning, the information contained in the discourse must be cognitively processed by the learner. Consequently the rate at which information is presented should be matched with the cognitive processing capabilities of students.

(Tobin, 1986, p 192)



Collins (1996) found that in her work with quiet children they seemed to benefit from an opportunity to rehearse their contribution to whole-class discussions, given time to construct it in their own terms. For other children, a pause may serve a similar purpose. The time to rehearse in their minds what they are going to say may give them greater confidence. It is not easy to be speaking and constructing your argument at the same time and yet this is often what we require of children. The quieter ones may fear that if they start speaking it will not be supported by their thinking. Rowe (1974) found that teachers waited more than twice as long for an able child to answer than a less able one. I might surmise this to be because they were more confident that the answer would eventually be produced by the more able. However, a less-able child might well need the benefit of the time to rehearse their thinking, as with a quieter child, before exposing it to public scrutiny.

The pressure is on the teacher, in the class situation, because whilst they wait for the one child the others might become inattentive, or so they feel. This may not, actually, be the case. Rowe found that the longer the pauses, the fewer the disciplinary moves the teachers made. It is possible to wait for the one and to expect the others to occupy the time processing the discussion thus far.

When a student is speaking they can pause to collect their thoughts and if a teacher interrupts during that time the flow is broken, both for the student who loses some of the elements of a half-formed idea, and from the point of view of the teacher who does not 'hear' the student's thoughts aright (Rowe 1974). Not only does the teacher need to wait when they have spoken but they need to ensure the child has finished before responding.

A further consideration for teacher wait-time is the claim made by Tobin (1986) that after a pause a teacher asked questions which helped pupils engage with understanding the material before them, rather than questions which just gave a pupil an opportunity to demonstrate present knowledge. I give an example on pages 110-111 (Bert, Gemma and Karen 8.3.99 pp 16-

17) where I did not ask open questions but waited and was helped to realise something of the pupils' train of thought. I was given needed thinking time.

I discussed the value of closed and open questions in sections preceding this one but as I examined my own performance I found that my response was fairly open when the pause was after a pupil speaking, but when it was after an utterance made by me I tended to supply an expected answer if the child did not speak first. This happened particularly after I had made an inappropriate demand. The benefits of waiting are not guaranteed. Factors such as the appropriateness of the preceding question, the context of the silence and the relationships existing between speakers have to be taken into account.

I wonder whether silence is so helpful when you are working with children individually? I tried to wait, but had the impression, sometimes, that the children found the silence intimidating, particularly in the conversation with Bert, Gemma and Karen 8.3.99. Maybe this has to do with teacher-pupil relations, maybe it has to do with the nature of the questions asked and maybe it was my lack of tolerance of the silence. Maybe in the one to one there is another way. Jawonski and Sachdev (1998) conclude that high levels of anxiety among students are likely to produce silence from them. This is very likely to be the case because they do not wish to make a wrong utterance and appear foolish. Too long a wait after a teacher has asked a question may well indicate a lack of confidence in the subject on the part of the pupils. In fact, Jawonski and Sachdev develop the theme by saying that teacher silence is often used in the classroom as a tool of discipline, a sign of intended dominance, and that it is not conducive to child participation. I do not have any evidence of this from within my data, but know that in the past I have used silence as a means of control in classes. Jawonski and Sachdev recommend that observational studies are carried out to compliment their research on attitudes towards silence to find out exactly how pupils do react. I believe such studies would have a contribution to make to the debate about teachers pausing more than the five seconds, as recommended by Rowe (1974).

### *Aspects of speculation*

In the study of classroom discourse carried out in Leeds by Alexander *et al.* (1996), referred to earlier, it was reported that five categories of teacher response accounted for 84% of all their verbal interactions. These five were “accept” direct response to pupil input; “direct” to request a non-verbal response; “elicit” question; “inform” to give a direct input and “reply” to make a response to pupil input which extended the conversation. These all show the teacher as being in control, the authority, evaluating and imparting knowledge, but what if the teacher abdicated that role in order to encourage pupil control of their own learning? Rather than asking open-ended questions, which pupils can still interpret as being teacher dominated, some researchers have found that pupils begin to overcome their reticence to take the lead in a conversation when the teacher speculates:

Teachers who give their own thoughts and ideas, who speculate, suggest or surmise, inform, interpret or illustrate or who simply listen and acknowledge what children have to say create a classroom climate which produces the mirror image of this pattern [referring to short-exchange IRF]. Even with pre-school aged children, I have found that youngsters will respond to speculation with speculation, hypothesis with hypothesis and suggestion with interpretation.

(Wood, 1992, p 209)

Hughes and Westgate (1998) make reference to this quotation from Wood in their study which sought “to identify, within relatively long stretches of discourse, any apparent key moves or sequences which might lead to, or support children in, more active and cognitively engaged roles with their adult talk partners” (p 174). They found examples of teachers building on previous responses from pupils and reflecting back to a pupil a summary of what they thought the pupil was saying. In doing so, the teachers acknowledged possibilities within what had just been said and gave expressions of approval, all in a speculative role. Hughes and Westgate felt

that such behaviour promoted cognitive activity from pupils beyond mere recall or expected connections. However, they did feel that their work was incomplete but shed light on seemingly profitable approaches.

A speculative manner on the part of the teacher can encourage pupils to explore a subject without feeling the need to fulfil teacher expectations, even though eventually their explorations may need directing along the line of the intended learning outcomes the teacher may have. "When students hold views different from those of the mathematics community, what or who challenges their conclusion and in what ways?" ask Chazan and Ball (1999 p 7). They then proceed to give examples of teachers who held back whilst students talked but at appropriate moments asked generic, neutral questions such as "What do others think?" or "Can you say more about what you were thinking?" There were times in my conversations when I held back, allowing the children to discuss and then found it easier to enter with a neutral question or comment because I was the listener, I was not directing, and only felt the need to prod the conversation when it was becoming unhelpful in mathematical terms, for example when working with Bill and Jay 26.4.99 pp 3, 24, & 33 (Appendix 2). The manner was speculative even if the actual wording was not.

Barnes (1976) described a group of children interacting with each other in what he claimed was a speculative manner. Edwards and Mercer (1987) subsequently challenged his findings on the basis that he had jumped to conclusions too rapidly. Nevertheless, the children in Barnes' study were shown to be deriving understanding from speculating about features of a picture depicting Saxon life. The conclusions they reached were those consistent with an understanding of the conditions facing Saxons. As Barnes maintained, children need to be questioning and evaluating the statements of others, rather than hearing with passive acceptance. When children's, or in fact, any listeners', minds engage actively with the dialogue they are constructing input in the light of their own conceptual understanding, restructuring and constructing an evaluative reply which not only enriches their knowledge, but also that of the people with whom they are in dialogue.

In Barnes' study, it was a discussion between children that was stimulated by a question from the teacher. As illustrated above, I feel teachers could participate in such a discussion if they were able to assume a similar speculative stance. By doing so, they model this evaluative style of contribution. I do not believe you can evaluate without mentally questioning because that evaluation has to be made against criteria and the mental activity is to ask how far the object of the evaluation measures up to them. The model of evaluating set by the teacher can help pupils to do likewise by seeing how it is done and copying.

Rowland (1999) would advocate that such participation, on the part of the teacher, requires the use of the inclusive pronoun, "we", not "you", to illustrate that the work is a joint exercise. This would further emphasise the right of the pupil to question the teacher's utterances.

To my mind, discussion stimulated by conjecture on the part of the teacher might contribute to a pupil's acquisition of 'principled knowledge' as defined by Edwards and Mercer (1987) where such knowledge "lends itself to reflective self-awareness, to "metacognition" (p 165). There is always a tension between encouraging pupils to form their own understandings of the world around them and initiating them into a culturally accepted body of knowledge. Mathematics is a domain of culturally accepted knowledge. How, then, does a teacher consistently speculate about knowledge they already know and wish to transmit in order to help their pupils to a principled understanding, rather than just ritual knowledge? I wished to grapple with this dichotomy when working with my pupils in order to address how communication can be used to establish and build on pupils' perceived understanding.

Flanders (1970) described a successful teacher as one who has the ability to take the ideas of the pupils and to sort them in terms of the learning objectives so those which were in line with the objectives were re-inforced, whilst those which were not so helpful to the objectives were valued, but not developed. I sought to test this when working with a small group of children

by trying to stimulate via speculation in order to elicit a variety of ideas. I found occasionally that, when my speculation was appropriate to their thinking, I could take their ideas and develop them along lines matching my learning objectives, but my skill in so doing needs further thought and development.

Perhaps an example to follow is one cited by Moyles (1997) of a teacher who articulated a problem with a set of pulleys and then waited for the children to suggest a way out of the problem. Upon success, the teacher then asked the children to explain why they had made the pulleys work and then, finally, to evaluate the experience. Of a more teacher-directed activity, Moyles writes, "The teacher needed to understand exactly what level each child was capable of achieving with her support - no mean feat" (p 18). By resisting the temptation to give the solution, the teacher was leaving the children to find their own levels of understanding, but still supporting them and extending their thinking at the appropriate juncture.

### *Points arising*

Key issues in relation to oral interaction between teachers and pupils include,

- \* when it might be appropriate to entertain an IRF sequence;
- \* how one might use open questioning, in a non-threatening way, to stimulate and support learning;
- \* the appropriate use of silence on the part of the teacher in order to give pupils time to order their understanding;
- \* the role of speculation in encouraging the joint enterprise of constructing understanding, both for pupils and the teacher.

### **A summary of the literature review**

I have examined the constructivist view of learning and made clear that I consider the role of the teacher as one who actively facilitates the construction of concepts within pupils. Many of the concepts will be ones held by the society in which the participants are operating. For my study, the domain in which the intended learning was to take place was mathematics

and I asked the question as to whether the learning should be couched in life-experienced concepts or whether children should be encouraged to appreciate the regular nature of number within the domain, able then to apply their understanding to situational problem solving. I argued for the latter. I moved on to look at how the teacher might encourage pupils to develop their concepts and skills, looking in particular at four discourse-facilitative approaches. All the previous points contribute to the answering of how a teacher might establish and enhance perceived understanding for pupils through oral interaction.

## **PART THREE: METHODOLOGY**

This section explains my methods for seeking answers to the research question posed. I approach it by looking at my work as being in the form of a case study, giving some context for the field work. I proceed with a description of how evidence was collected and analysed before considering my role in the activity.

### **An Ethnographic Case Study Approach**

The study I undertook was of the nature of a case study, giving insights into the interaction of an adult, myself, with nine children during a series of sessions spread over a year, working with some individually and then with them in small groups. My intention, first and foremost, was to view my own practice in order to identify approaches which could contribute to an improvement. Secondly, I, now, hope to find out insights which I could pass on to the classroom assistants who I train on an accredited course. Thirdly, it is hoped that something of what I discovered might be of help to teachers, as well as being a contribution to the body of knowledge in this field. The evidence gathered was essentially qualitative.

The goal is not to produce a standardised set of results that any other careful researcher in the same situation or studying the same issues would have produced. Rather it is to produce a coherent and illuminating description of and perspective on a situation that is based on and consistent with detailed study of that situation.

(Schofield, 1993, p 93)

It is my task to present the reader with that detailed description and my perspective on the situation so that they can take from it whatever is of value for themselves.

The research question addressed in my study was, "How can teacher-pupil communication be used in the teaching situation to establish and build on



pupils' perceived understanding and thus enhance learning?" It has to do with process, interactions and discourse between teachers and pupils, as well as the construction of understanding, how things happen and why (Anderson and Arsenault 1998). In order to study the phenomena, I turned to methods of investigation which were of a qualitative nature, ethnographic in approach.

Ethnography not only implies engagement of the researcher in the world under study; it also implies a commitment to a search for meaning, a suspension of preconceptions and an orientation to discovery.

(Ball, 1993, p 32)

First of all, my work exhibited an involvement in the world under study because it was my own actions which were under particular scrutiny. Then it involved a search for meaning because without it there was little value unless new meanings or reasons for working in a certain way were discovered. I also wished to approach the work with a willingness to have preconceptions challenged and new discoveries made, a process which has, indeed, taken place.

I was involved as the focus of the study but I needed to examine how far my involvement led to unacceptable bias as far as drawing out from my experience something which is of value to other people. A detailed examination of my role appears in the section entitled, 'a proper subjectivity'. Sufficient now is to say that I cannot but come to the study with all the beliefs and experience of the past but I hope that the preceding conceptual framework in part two has contributed to setting the context of my own present thinking by which the work may be judged. I believe the conclusions to be as fair a reflection of practice as possible, so that the search for meaning is real and not a fabrication of distorted perceptions (Eisner 1991).

As for the suspension of preconceptions and an orientation to discovery, I wished my study to be a voyage of discovery where succeeding horizons set the course for the next enterprise within the whole. Researchers (for

example Barnes, 1976; Wright, 1993 and Rowland, 1995) have sought to gather data and then analyse it to discover themes, a deductive approach. My study was more inductive in nature (Anderson and Arsenault 1998), progressively focused, where early stages of field work or reading set the agenda for actions which follow, a model used, for example, by Nias (1993) and Ball (1993). Indeed that was the case, as far as how I structured sessions and considerable insights into my behaviour have resulted. Roskos, Boehlen and Walker (2000) conclude that when they studied teachers engaging in self-reflection on discourse in video-taped lessons, at first glance the teachers did not seem to have moved significantly and that they seemed to have seen what they wanted to see. A second investigation revealed “evidence of active understanding: teachers constructing concepts, weighing evidence, and clarifying goals” (p 248). Maybe it takes more than a limited period of reflection on praxis before a teacher has internalised changes and is able to adopt them in the immediacy of a classroom situation. I intend to continue bearing the conclusions in mind as I teach and to seek a continuing change in practice as a consequence.

### *The school context*

Seaview School is a Junior school concentrating on Key Stage Two pupils. The site adjoins the Infant school from which most of the pupils are drawn. The stone buildings have been in place for about forty years so that most classrooms are of a traditional design.

The location is within a fairly close-knit community, fiercely protective of its history and heritage, an urban/rural setting. Up until recently, a number of the children would have been drawn from service families and even now some of the families are from ex-service personnel. The school has twelve classes of around thirty pupils in each, three to each year and the children stay with their class teacher for all subjects. Within each year, the children are distributed across three parallel classes according to social considerations, rather than attainment, a process reviewed annually when re-distribution takes place.

Standard Assessment Test results for Mathematics have risen year on year and now stand just above the national average, although staff do not attribute this to any particular policy decisions, more to do with the abilities of the yearly intakes. The children work in class groups for mathematics with the foundation of a printed scheme. However, this is not followed rigidly and the teachers use it in a flexible whole class approach. At the time of my research, I observed that the lessons followed the pattern of an introduction and discussion as a class, individual or pair work on the subject in hand, differentiation tending to be by outcome, although a child needing help or extension might be given extra activities. This may have changed now with the introduction of the Numeracy Hour. Of his sessions the teacher of the year five class said, "In the format of the lesson I would be introducing the concept, talk, mental work, and then practice... the following lesson would be a similar sort of idea but the talk would be ... we start off with revision, as it were, just to make sure the concepts have been understood" (P.Y. 10.3.98).

### *The selection of children*

My primary source of information was through tape-recorded conversations with a small number of individual children, working on their own or in groups, beginning with one I call Jay (the names of all children in the study have been changed). The selection of Jay was opportunistic. He was available for my study, of the right age and with motivation to co-operate. My age focus was Key Stage Two and I decided to work with children in year five because of their length of experience in that key stage as well as the length of time they had left in which I needed to work with them. I wished to focus on children whose experience of education was similar to that of many children in this country in order to facilitate relevance for possible readers to their own situation.

In order to allow for the possibility of working with some pupils in small groups, I approached Jay's headteacher and teacher for the selection of another five children from his class. The specification of the same class was to work with children having similar experiences of education. The selection

was made on the basis of gender - equal numbers of boys and girls, and a range of attainments (see Appendix four for year six results). The selection was not made on any definitive criteria because the actual performance and progress of each child was not the issue in my work. I just needed a range of abilities so that my responses to their understanding, as I perceived it, were likely to be typical of the responses a teacher might make in a class with a similar range of abilities. This would allow for relevance to their own situation for possible readers.

The intention of working with children in small groups was to facilitate exploration and discussion. I elected to work with those small numbers, rather than a whole class, because I wanted to study the detail of how individual children responded to my inputs, how they developed their thinking and interaction. With a large number at once, the thinking of one child would be masked by others. It could be said that the outcomes of conversations with a small group of children by an interested adult have little to do with the outcomes a teacher might have when discussing a subject with a whole class of children. However, as my intention was to try and trace the changes in thinking taking place within the understanding of a single child this is a highly appropriate strategy. Such focus on individual learners is especially timely as discussion in groups is, now, not alien to the Key Stage Two classroom because teachers, and their assistants, are encouraged to work at length with a few children within the context of the Numeracy and Literacy Hours (DfEE 1998 p 12; 1999 p 14). Rowe (1974) came to the conclusion, after analysing many tapes of teacher interaction with a variety of group sizes, that "whatever pattern the teacher exhibited when working with four children closely resembled the pattern displayed when carrying on a discussion with a whole class" (p 205). Based on her work, I would suggest that the outcomes from my group discussions might be replicated in a normal classroom situation.

The issue of "informed consent" is an important one. Attrichter *et al.* (1993) say, "the pupils (or other interviewees) are told what use will be made of the data" (p 78). Anderson and Arsenault (1998) write that, "Participants must

be informed of the nature and purpose of the research, its risks and benefits, and must consent to participate without coercion” (p 18). Are pupils in a school able to give consent without being coerced? The teacher is in a position of power, and I, as an adult in the school, assumed some of that power. The children came to work with me because they were told to, but all expressed a positive attitude towards the experience, perhaps because I was the one asking. However, as an example of limits to the coercion, one child did withdraw from working with me on his own, returning only when accompanied by his friend. Anderson and Arsenault (1998) do allow for parents to give consent on behalf of minors and I did write to parents enclosing a permission slip. They were assured of anonymity and encouraged to consider the activity an opportunity for their children of concentrated individual and small group exploration in mathematics, so had some concepts of the benefits, as expected by Anderson and Arsenault (1998). However, Eisner (1991), earlier, raised the question as to whether a researcher is able to anticipate what will happen, what will be the risks and the benefits. I have called my study a “voyage of discovery,” hardly a scenario in which I could give either parents or pupils details of implications before the event. The pupils were told that the focus was on my performance, rather than theirs, the most I knew at the beginning of the enterprise.

Eisner (1991) questioned whether anyone can be fully informed “if they do not have the technical sophistication or expertise to raise questions that someone more sophisticated would raise” (p 217). This is a dilemma and certainly, in the case of children, a living issue. Eisner does not have the answer, and neither do I, except to join him in saying that in life today our privacy is often invaded. By means of changing the names of the children and not giving the actual name of the school I have sought to protect them as far as possible.

The class teachers were interviewed, using a semi-structured technique, covering aspects of their work such as their approach to the subject; which scheme of work they used; how they organised the teaching and learning;

and what they felt about current debates. They kindly allowed recordings of the conversations, which were offered to them for review, as well as observation of lessons so that I was able to gain insights into the experiences of the children within the focus domain.

### *The cycle of data gathering*

I was a visitor to the school in which I undertook the fieldwork, entering for the sole purpose of carrying out my research, during weekly visits in a summer term and the following spring and summer. I withdrew children from their classrooms to a quiet place, annex of classroom, library or staffroom. The withdrawal took place during mathematics lessons so that my activity complemented the pupils' normal routine.

During my pilot study, I recorded and transcribed a conversation, lasting about three quarters of an hour, with one child, Jay, analysed the outcome in order to find out how I used language and what strategies I used in order to help him explore the problem he, himself, set. After reflection, I held two half-hour conversations with each of six children individually. The first conversation had a focus on establishing understanding, and the following one on developing that understanding. Again, after reflection, I moved to working with children in groups. The first two groups consisted of the same children with which I had worked as individuals, bar one who had left the school. The third group was constituted from three children with whom I had not worked before, two girls and a boy in order to keep a gender balance. With each group, I worked for three one hour sessions, giving nine hours work all together. In the fourth session with each group, we reflected back on the experience of working with each other in order to gain the pupils' perspective of my activity.

The process I have described above could be conceptualised in a way similar to the diagram given by Lofland and Lofland (1984 p 132) and interpreted by me as follows:

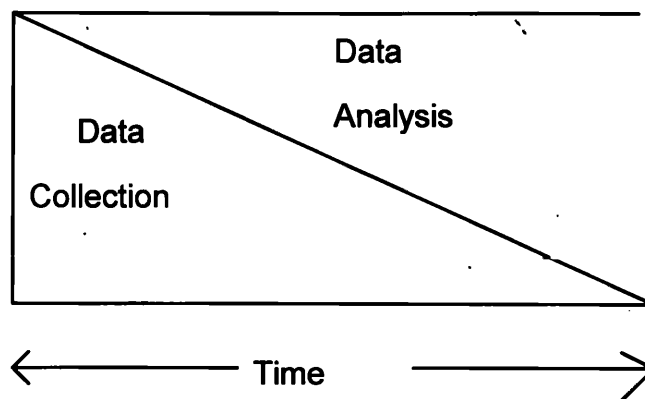


Fig 3.1 The process of data collection and analysis.

The collection and analysis of data takes place alongside each other and feed into each other but as time passes the collection gives way to the analysis. Ely *et al.* (1997) say that even that is too simplistic, “the interweaving of data collection and analysis is highly transactional, each activity shedding light on and enriching the other” (p 165). I resonate with that description, although it seems to me to give a high status to what appears to be a natural evolution, and one which, given the time constraints, was not as clear cut as the diagram portrays. There was time to reflect between each round of data gathering but not between sessions. The most I could do was listen to the recording, and, therefore, change in my behaviour caused by reflection on my interactions with particular children was extremely limited.

I used audio recording for all conversations. Although the use of a purely audio recording means that it is not possible to capture the non-verbal contributions to the conversations, such as gesture and expression, the focus of my research was on the oral response of the teacher and thus the clarity of the sound was paramount. A video recording would provide a fuller context but it is more difficult to gain clarity of speech unless an extension microphone is used. In addition, the presence of a camera might well be intrusive due to its obvious presence. Two small tape recorders sitting on the table seemed more easily forgotten, as I can testify. Generally, the children were prepared to ignore them as well, making but one or two references to them. Even this, I feel, had something of an inhibiting factor, particularly at

the beginning of conversations, and I needed to be aware during analysis of the possibility that the data might be affected. All recordings were transcribed in full and analysed as described in the next section.

As a background to the sessions with children I initially established weekly access into the classroom and assisted with the teaching of mathematics to the whole class, which helped to establish a working relationship with both teacher and pupils. I also kept a research biography, “a reflexive account of the conduct of the research which ... recounts the processes, problems, choices and errors” (Ball 1993 p 46). In it, I recorded thoughts, reflections, impressions, ideas for future action. This gave an insight into the process of my own learning and construction of understanding.

The discoveries I did make, it is hoped, will be of considerable value to myself and, possibly, to other teachers but Hammersley sounds a note of caution:

Reflection and inquiry, however “systematic” and rigorous”, are not guaranteed to produce advances in useful understanding ... Furthermore the products of systematic inquiry will not necessarily be better than the presuppositions built into traditional ways of doing things.

(Hammersley, 1993, p 224)

Hammersley seems to imply a low expectation of a great deal of systematic and rigorous work. Surely even if the outcomes are no better than actions based on intuition or a continuation of tradition they add confirmation and legitimacy to existing practice. I expected to make new discoveries but needed to be open to the possibility that such an enterprise would only serve to confirm what is already well known and exercised frequently in classrooms around the world. Possibly this can be said to be the case, but I believe that my work serves to exemplify and extend the thinking of others, as discussed in part two. In one sense the investigation was new, for no one has researched these particular children’s understanding or my responses at this depth previously, and everyone is a unique human being.



## **Ethnographic Transcription and Analysis**

Each conversation and interview which was recorded was later transcribed by me from the two tapes of each session. The two afforded insurance against recorder failure; a fuller coverage of conversation than would be the case with one; easier identification of speakers and a means of checking the transcription, which was completed using ordinary tape recorders and earphones.

Representing on paper the intonation inflections and emotions portrayed on the tape was a challenge, addressed by the use of punctuation, but always less than complete. I chose to represent pauses by a line of dots, the length of line relative to the duration of the pause. If the pause was lengthy, I timed it with a stopwatch during transcription in order to facilitate a study of "wait time" (Rowe 1974). A copy of an excerpt from a transcript is included in Appendix 1.

Various layouts for transcriptions are illustrated in the book by Edwards and Westgate (1994) with the advice "include in the transcript whatever features are necessary to the researcher's purposes" (p 64). Because of my desired emphasis on oral communication, I chose to lay the discourse in the left-hand column of the paper with room alongside to write a free commentary; between speech moves to write categories of move, developed by myself, and in the left-hand margin to add strategies. The main action taking place during recordings was that of writing on paper so all papers were kept alongside to illustrate the discourse and where even this did not make the actions clear a description of what someone was doing was added to the transcript in italics. The focus of my study was on the verbal interactions between participants and the building of their understanding so the commentary alongside needed as much space as the original transcript in order to give room for my reflections on the action and speech.

Edwards and Westgate (1994) include in their book some layouts which have a column for each speaker because there was so much overlap, two

people speaking at the same time. In my transcript, where this occurred, I bracketed the overlapping words together, but it did not happen too frequently, probably because of my presence which acted as a reference point for the pupils, or a chair of the proceedings, however much I tried to become one of the group. The transcripts which Edwards and Westgate display were between pupils alone, peers with no chairperson. Our group conversations probably resembled a different kind of dialogue from one emanating purely from a group of peers. In the analysis, I was studying my interactions with the children so theirs with each other were of slightly less importance to me. Therefore I did not find the multi-column layout necessary or desirable.

In part two, I entered into a discussion of various approaches to discourse analysis, for example those of Sinclair and Coulthard (1975) as well as Alexander, Willcocks and Nelson (1996). I found that none of the methods for analysis satisfied the purpose for which I wished to examine the transcripts and therefore I developed my own. It is interesting, however, that back in 1977 Borich and Madden were pressing for standardised instruments of analysis as a way to enhance the generalizability of research into discourse.

It was apparent that researchers preferred to develop their own instruments, rather than to use or adapt those already constructed for the same or similar purposes. This emphasis on new instrument development seems to have reduced the opportunity for researchers to improve upon existing measures, to replicate an instrument's reliability and validity, and to use the same operations to measure the same constructs.

(Borich and Madden, 1977, p 3)

In ethnographic study, the emphasis is on the search for reality in the situation, not reliability across differing events. My response to them would be to say that if researchers are seeking to further understanding of a particular subject they are not going to be satisfied to be replicating or

measuring the same constructs. They are doing a new thing and it needs new instruments to understand that new thing (Woods 1986).

The analysis process is systematic and comprehensive, but not rigid. The process itself emerges from the data and the purposes of the study.

(Ely *et al.*, 1997, p 163).

It is with this later observation that I would agree. My analysis developed consistently throughout but the style emerged as the purpose of my study, to look at my responses and how to enhance them, was clarified because it was based on what I needed to know.

I looked at the text in three different ways. The first was to write a free-flowing commentary of what I felt was happening for each participant as a result of the evidence in front of me; my memory of my own thoughts and feelings during the event and also the demeanour of the learners. The second approach was to look at each utterance I had made, since it was my behaviour that was most under examination, and seek to put it into a category based on its function in the discourse. As Woods (1986) said, "What the categories are depends on the kind of study and one's interests" (p 125). I tried to keep the number of categories to a manageable number which meant that at times two utterances given a particular category might vary very slightly in function. If an utterance really did not align with any existing category then one was added, an act which was unnecessary in the later stages, thus proving the appropriateness of the scheme in a measure given by Woods (1986). It is a technique described by Atkins (1984). The third approach was to look at a sequence of utterances which contributed to a particular strategy on my part in dealing with my perception of the child's understanding (see Appendix 3).

### *Comparison of data with theory*

Examination of the data caused me to identify aspects of the discussions which were pursued at greater depth in subsequent conversations. This was

in order to find out more about those aspects and seek some answers to the question of how pupil-teacher communication can be used to enhance learning. My, subsequent, reading around those subjects allowed me to see whether my evidence supported, contradicted or developed existing arguments, as well as giving me a position in relation to the thinking of others (Woods 1986). As I worked I was seeking to find out answers as to how could I improve my performance; how I could find something of value to help others and what happened when various strategies were employed. In all this I needed to show that it was likely learning took place. This is difficult to demonstrate, but a strategy cannot be said to have been successful unless there is learning, the object of the exercise. The outcomes from examination of my work follow and some answers to these questions are more apparent than others. It has to be remembered that I, or a teacher, might be successful with certain strategies in some situations whereas they become less useful in others whether they are with individuals, groups or a whole class.

### **Participant Researcher**

Because it is my behaviour under scrutiny my role in relation to the children needs examination. To some extent my research can be described as participant observation (Ghail 1991; Lacey 1993) because, although I visited the school for the sole purpose of carrying out my study, I did have a limited input into its life. However, I was not the class teacher so there were other influences at work which had to be taken into account. The work of the teachers with their children must have influenced what I was able to do because their input provided the experiences with which the children were

familiar and through which those children had constructed their understanding underpinning my conversations with them. Indeed, I only had a minute input into the understanding of the children but that does not invalidate the research for it was what happened when I was with them which was under scrutiny. I sought to identify and evaluate strategies used by myself whilst endeavouring to support learning.

The disadvantage of such an approach was that I was not involved in the day-to-day school lives of the pupils and, therefore, unable to draw on such knowledge when talking to them. My knowledge of them was restricted to their performance in mathematics and that only partially because they spent far more time with their class teacher. I did not have a holistic knowledge of the children, their learning and attitudes in other subjects as well as home backgrounds. Lives out of school may well have a significant influence on reactions in school, including a context in which subjects are discussed. However, with a focus on my performance in my work this lack of knowledge about the children, a possible distraction, may have helped to focus my attention, during analysis, on the actual discourse itself.

If the children saw me as other than a teacher, their responses to me may not have been typical of teacher-pupil interaction, encouraging an attitude that time spent with me was time spent away from learning. They did know I had been a headteacher and I sought to behave in the school as I would have done in my own, requiring standards of behaviour and dress with which I was comfortable, and which I saw being upheld in the school. On the other hand, being seen by the children as outside the disciplinary structure of the school, and therefore one in whom they could confide, could be an advantage. I certainly felt that as I was sometimes employing strategies with which pupils were not totally familiar it was easier for those strategies to be accepted as 'the way of the visitor'.

I was in the privileged position of being able to concentrate on the few children for extended periods of time, studying teacher/pupil oral interactions at greater depth than is usually possible, without any other distractions that life in a school can bring. I did not have to feel under any pressure from colleagues to be undertaking other duties and my reflections on our conversations were unencumbered by remembrance of other conversations held outside the sessions.

I went into someone else's classroom and worked with children from that class. However, I claim my activity was still theory-guided (Carr 1993)

reflective research because it was my practice which was under scrutiny, not that of the teachers of the classes. They were the facilitators of my access to the children and situations with whom and in which I was working. My intention was that my skill in helping to develop understanding in the children with whom I worked should be enhanced, but that also an account of my work might help teachers who read it.

### *A proper subjectivity*

Ethnographic study has the features of seeking to explore the nature of things by looking at a small number of cases, often using data which is natural in context, i.e. that which is a result of natural happenings at the point of collection, not pre-planned, other than the normal planning for learning undertaken by a teacher before a session. Bird and Hammersley (The Open University 1996) claim that ethnographic analysis involves the explicit interpretation of meanings and functions of human actions. The analysis of transcript material from my discussions with pupils is by its nature an interpretation of the meanings we gave to our utterances and the functions of our actions, but that interpretation was made by one of the participants, myself. The outcome makes possible a useful record of what actually took place. As to whether it can ever be “ontologically objective,” giving “an undistorted view of reality” (Eisner 1993 p 50), there must be considerable doubt. For a start, my presence and work in the school was an unusual happening (Ball 1993) and I needed to be aware that the children may well have been confused as to the purpose of my visits. It is difficult to explain to a ten-year-old that you wanting to learn more about how to improve your teaching and that they are, in effect, acting as research assistants. That is hardly a real situation for teacher and learners and yet the roles we played were roles familiar in everyday life. Therefore there was a naturalness about our interactions.

It has to be asked whether, in the course of my study, I can analyse my praxis, “informed, committed action” (Kemmis 1993 p 182) sufficiently objectively to bring about an understanding of what has gone on between myself and the children.

A problem seems to arise about whether the practitioner can understand his or her own praxis in an undistorted way - whether understandings reached will be biased, idiosyncratic ..., or systematically distorted by ideology.

(Kemmis, 1993, p 183)

It is difficult to challenge this statement because who can say whether anyone is understanding a situation without bias or the imposition of a personal conceptual framework on the evidence brought forward. As Woods (1986) said of ethnographic description, "it is in itself theoretically laden" (p 152), or as Attrichter, Posch and Samkh (1993) say, "Whatever is produced or selected as data depends on the interpretative processes of the researcher ... experiences which have been recorded by the researcher are theory laden" (pp 70 - 71). Therefore, more realistic, maybe, than denying bias is the position where a personal position is identified, articulated, and used as a reference when analysing evidence. However, I believe that making a transcript and then reflecting on that does remove the event one step away from the actors.

In transcript the word is made manifest as a random-access witness to the event. The text is now a transformed object in the world, tangible and accessible for study in its own right. For me this transcription of tape into text is a significant means of achieving detachment from the interactions in which I participated.

(Rowland, 1995, p 19)

To a considerable extent I agree, but the reflection, carried out by one of the original players, myself, does come from the same mind with the same prejudices, the same patterns of thought and the same conceptual understanding. There is a detachment by analysing the transcripts but there has to be a bias in the interpretation of the evidence for all of us hold to particular positions through which we see the world (Attrichter *et al.* 1993). It is for the reader to judge whether the conclusions I reached were based on a distortion of reality or have sufficient validity to be taken seriously.

Good work ... is still - at best - only tentative. But the good work ... will be objective, in the sense that it has been opened up to criticism, and the reasons and the evidence offered ... will have withstood serious scrutiny.

(Phillips, 1993, p 70)

Whether opening it up to scrutiny and criticism makes the work objective has to be debated. It gives a rigour to the process but the person who seeks to reach a view of the evidence by cutting corners, by engaging in methods which are anything but thorough, shot through with individual prejudices may just come to as near a true conclusion as someone who takes infinite care, except that their conclusion is reached by accident rather than design. The more conclusions are reached in the light of theoretical perspectives, the more likely they are to have been influenced by the observer's interpretation of those theories, a point made by Anderson and Arsenault (1998). My work is no exception and has to be viewed in the light of my perspective, that of a social constructivist, elaborated upon in part two.

My stand as a social constructivist is enhanced by my knowledge of my own context for my work. I needed an awareness of my own perspectives and this should have given greater insights into the discourse taking place.

Educative research does not claim to remove bias and produce objective accounts of reality.

(Gitlin *et al.*, 1993, p 207)

I agree. Even Eisner (1993) himself claims that it is not possible to present reality in unadulterated form. How can one reflect in one medium (the printed word) what has gone on in another, the minds of two people as they interact with each other? For Stenhouse, writing in 1975, this would not have been an issue in a study where the teacher is looking at their own praxis, "it is the teacher's subjective perception which is crucial for practice" (p 35). Such perception, influenced by perspective, influences action.



Notwithstanding this, I think it is important for my work to be as rigorous and authentic as possible because it is only then that teachers can relate any of the findings to their “reality” and use them to illumine their own practice. That is why I have sought to make clear the theoretical stance I hold; the situation upon which my work is based and evidence presented in as unadulterated a form as possible. What I choose to present of a vastly complicated situation and from hours of work will undoubtedly influence the perceptions of it made by any reader. That is inevitable and therefore even if my work is “good” it remains tentative. Kemmis (1993) puts this point when he states that “since only the practitioner has access to the commitments and practical theories which inform praxis, only the practitioner can study praxis” (p 182). I may be the only person who understands the foundations for my actions and the way I approach my work with children but if so can I expect other people to enter into that understanding in any meaningful way? Am I the only person who can learn anything from this study? I think not. I see within it confirmation of the thinking of others, as shown in part four. However, the reader will need to interpret what I pass on as my learning in the light of their own situation and needs.

### **Conclusion of Methodology**

My approach was one of an ethnographic case study where “investigation of a relatively small number of cases selected consecutively rather than simultaneously, so that analysis of data from earlier cases influences the selection of subsequent ones” (The Open University 1996 p 59). The theoretical stance taken on learning was within the social constructivist tradition, seeking through oral interchanges to reflect on and construct meaning, and this was applied to my methodology in undertaking a form of evidence based research. It was my behaviour which was the focus of the study, and during it I hoped to construct an ever deepening understanding of how learning can be supported, by me and by others.

## PART FOUR: FINDINGS

What follows is drawn from an analysis of all the data gathered showing how the issues highlighted in my literature review were developed as discussions took place with my respondents. Further illumination of the comments below may thus be gained by reference back to the place in the review where the work of the particular named authors is discussed.

I am addressing the research question of How can teacher-pupil communication be used in the teaching situation to establish and build on pupils' perceived understanding and thus enhance learning? In order to attempt a possible answer, I needed to simulate, as near as possible, conversations a teacher might have with pupils about their work. I chose to take as stimulation for our discussions aspects of mathematics, particularly number, under discussion in the children's classroom and approaches which I felt might help me explore issues of concern to me. The question underlines the overwhelming conclusion to which I was drawn and that was that unless the adult has established, as far as they are able, the present understanding of the child they cannot hope to develop that understanding and encourage learning. Listening is vital. First, some of the discourse strategies I employed within the context of the need to listen to responses or initiations made by the children with whom I was speaking are explored. Following that, another strategy, speculation, is given attention before a consideration of the context in which mathematical concepts might be presented.

My initial discussion took place in 1997 with a boy I called Jay talking about a mathematical problem of his choosing. The intention for this conversation was that it might give rise to a consideration of oral strategies which were employed. Several issues became evident and they are raised in the first section of this analysis. These were then followed up within conversations with individual children and then small groups, and as I did so, at least one other issue emerged. When I spoke with Jay, on this first

occasion, I did not set out with the intention of finding out something of what he knew in a facet of mathematics but to help him with a problem he faced. Retrospectively, I consider that this approach probably caused me to move into an instructional mode far too early in our relationship. However, reflection on the conversation revealed several discourse strategies which I used and which I felt were worthy of further exploration. It also raised in my mind the question of whether one could, or should, convey numerical concepts through the use of situations familiar to the child or whether number should be addressed as patterns to be understood and then used in situational calculations. This is how part of the first, exploratory conversation proceeded:

Jay                Um ..... (Writes  $1000 - 80$ )

Researcher      Let's have a look, see what you've got, right.

Jay                That's what I'm really stuck with.

Researcher      You're really, really stuck with that. OK. How do you think you might try and do that first of all?

Jay                Well if I .....

Researcher      Can you read it out for the tape? So we've got it on the tape.

Jay                OK. A thousand divided by eighty.

Researcher      OK. Fine. Now ...

Jay                I think if you put the thousand at the top then you put divide at the side then you put eighty ... there, just, um and er in the tens and thousands, no hundreds and thousands and then you, and then you got to divide nought by nought ... that's nought and that's nought and then that's nought again and

then one and one and nothing, one, so that makes another thousand. That's wrong.

In this first section, I followed Jay's agenda and invited him to demonstrate. The request to read the question for the tape was partly an excuse to find out if he could read what he had written, which, indeed, he could. Whether he understood what it meant, was the point I pursued. In hindsight, I feel I should have picked up on his last comment and asked a more open ended question about why he thought what he had done was wrong which might have led me to gain a deeper insight into his thinking than I did. It would have provided me with a chance to listen to him. Listening in order to ask an appropriate question, is a subject which will be explored in more depth throughout this section.

Returning to my examination of data, I chose understanding of division, asking a closed question, wresting the initiative from Jay, but seeking to clarify in my own mind whether he understood the task. What followed was a sequence initiated by me, responded to by Jay and then followed up by me, (IRF):

Researcher     OK. Can I ask you a question? When you are trying to divide, what are you trying to do?

Jay             Oh. I'm try ..... If you got .... um ... numbers like eight and nine or something you got ter see how many eights there are in nine.

Researcher     Right, so you're seeing how many lots of ...

Jay             Yeh.

Researcher     OK .... so .... You're trying to find out with that sum how many lots of eighty there are in a thousand.

Jay                    Yeh.

Researcher        OK. ... Um ... How? ... You've put it down like that and you've said that's wrong. You've put it with the eighty underneath and then the thousand. OK. How could we find out how many lots of ... um ... eight there is in a hundred, do you think?

By taking the lead and asking closed questions I lead Jay along a path where his understanding could well be tenuous. I made a huge assumption that he would see the connection between dividing eight into a hundred and eighty into a thousand. I did this because I felt it would be more manageable for him to understand, but he would have needed a clear understanding of place value and ratio to have understood the point and this, I doubt, he had. In addition, I rephrased his answer to the question about division into terms I wanted to hear, but it might not have been what he really meant. We continued:

Jay                    Um ..... put ..... a hundred divided by eight by eight and .....  
.....

Researcher        Try not to think about the sum, try and think about what we're doing. Suppose you've got .... a pound, which is a hundred pence ..... right?

Jay                    Yeh.

Researcher        You've got a pound and you've gone to buy sweets for eight pence each. OK? How, how would you go about working out how many sweets you could get for a pound?

Jay                    Um .. you get .. you .. um .. er .. you could get it if you divide the um hundred into ... uh ... eights.

Researcher     Yup.

Jay             So it would be a hundred .... eight ... how many tens in a hundred that's nine, so how many nine eights. These are the things I get stuck with as well, so nine eights.

Researcher     OK. Let's stop there. Why did you say how many tens in a hundred?

Jay             Um, because in a ten there's eight so every eight I can do, there'll be some money left over.

Had he been helped by couching the problem in the form of one to do with money? It is difficult to tell but it seemed that it was possible because he showed an understanding of approximation and related it to money on his own volition. He was probably familiar with the idea of handing over a ten pence piece if he was spending eight pence and he knew there was a number of ten-pence pieces in a pound. This, which was situated cognition, needed further exploration and I return to it as focus for later discussions. The conversation proceeded without further reference to money:

Researcher     Good. OK. So you are saying that eight is near to ten.

Jay             Yes.

Researcher     And therefore the easy way to do it would be to share it into lots of ten. ... That's what you're saying?

Jay             Yep.

Researcher     Good, fine. You're right. That's brilliant. So, um ... how many lots of ten in a hundred?

Jay             Nine.

Researcher Are there?

Jay Um ..... um ..... no.

Researcher Have a think.

It is interesting that he seemed to assume my question indicated an error, this being born out by my encouraging of further thought. In this case his assumption was justified but at other times I did challenge with a question after a correct answer in order to check understanding.

Jay Um ..... ten.

Researcher Do you think so?

Jay Um .... don't know.

In our discussion, we were proceeding to use approximation to move us forward with the problem, an aspect of number which I picked up in later conversations but do not examine in detail in this analysis.

Researcher How could you work out how many lots of ten?

Jay You could ..... you could put a hundred down in lines on a piece of paper, like a way every, you count up to ten then you put a line, a big line, so that it stops there and another ten, keep on going till you get to the end ... and then count how many there are.

Researcher You could do it that way, good ... or ... have you ever used a number square?

Jay No.

Researcher     You don't know what a number square looks like?

Jay             Oh yeh, um one of those things where it goes one to ten at the top.

Researcher     That's right.

I turned the conversation to my own conception of what to do, even though Jay had a perfectly good idea. I should have allowed him to continue but instead we entered into a protracted period of number square construction which diverted us from the main purpose of our need for a hundred in tens.

Jay             One to ten at the side and then there's one to a hundred in the middle so, and you can do your times table by looking at the top .... like if you're doing .... two, there's different ones like times and adds and stuff and if you're doing times .... if you need to work out two times ... three you just find the three at the top, look down the side and then um, go along the lines till they join up and that number there is the answer.

Researcher     Right. You're talk, you're right. You're describing a multiplication square.

Jay             Yeh.

Researcher     Now there is another kind of square, which you may not have used, and it looks a bit like this. It has one and goes along until it gets to ten, right, and on the next line goes eleven and goes along 'till you get to twenty, and the next one goes from twenty-one, goes along 'till you get to thirty. Have you seen one like that? (*Drawing grid whilst speaking.*)

Jay             No.



Researcher     Right. OK. Goes on thirty-one 'till you get to forty, right, and then from forty-one goes on 'till .. 'till you get to fifty .... fifty-one goes on 'till you get to ...?

Jay             Err ... um, sixty.

Researcher     Right, what am ... what am I going to put next?

Jay             Um .. sixty one.

We proceeded to work together, Jay telling me what to do until we got to a hundred. This was the beginning of a change in our relationship, working collaboratively, rather than my asking questions and Jay answering. How one develops a collaborative working atmosphere was an issue addressed as I continued with my discussions. When we reached a hundred, it was back to my initiation of the thinking.

Jay             Hundred.

Researcher     One hundred. OK. How many counts in each of those lines?

Jay             Ten.

Researcher     Ten. All right, so that's ten. Where we started was you are trying to find out how many tens in a hundred, right?

Jay             Mmmm.

Researcher     So that's ten, isn't it? (*Indicating the first line.*)

Jay             Yeh

Researcher     That's another ten.

Jay Yeh.

Researcher So how many tens in a hundred?

Jay One, two, three, four, five, six, seven, eight, nine, ten.

Researcher Ten, right. Ten tens in a hundred.

Jay Yup.

Researcher If you had ten ten penny pieces you would have a pound, wouldn't you? Right .... so ..... The reason you wanted to find out how many tens there were in a hundred was because eight is near ten and we're starting out with the sum, how many eights in a hundred. That was the sum we were doing, OK? And you said there are .... that eight is near ten and that there are ten tens in a hundred. We've got to now so where are you ... what are you going to do now to find out how many eights in a hundred? If there are ten tens in a hundred.

Jay Um .... um .... do ten add eight. No .... um .... ten eights is .... uh.

Researcher Right. OK. You've got .... ten ..... (*writing one ten*) OK? No. You're trying to find out how many eights there are in a hundred, not how many tens there are in a hundred.

(Jay 30.10.97 pp 2-7)

I had confused him and no wonder. He was beginning to translate the problem into his own terms, by thinking about ten eights (earlier he had spoken about nine eights), but I cut him off and continued in my own way of thinking. I should have waited, given him time to follow his line of thinking and then have supported him in it. Wait time is another issue which I pick up later and think about in more detail.

As was indicated earlier, I touched on several discourse strategies within this conversation namely, IRF, using open questions, waiting and encouraging a collaborative approach and these I followed through in later discussions. The collaborative approach led, in one of those conversations, to an exploration of the more knowledgeable adult using speculation. On occasions, aspects of a strategy emerged in the course of the discussion, at other times I sought to modify my behaviour in order to employ certain strategies, thus facilitating further consideration. In all this, my ability to perceive, with some degree of accuracy, the understanding of the children, to have listened accurately, emerged as the vital factor. Before examining some strategies through the medium of listening an explanation is given of why certain topics were being discussed.

In later conversations with individuals and small groups topics were sometimes chosen to facilitate the following up of issues from this discussion, but, in addition, other topics were selected because they were current in class work of the children. As the discussions took place over a period of time, the topics considered varied, making the excerpts included in the evidence presented here seem somewhat fragmentary. They are included to illustrate a point, not necessarily to chart the development of the children's thinking through a topic.

### **Listening when phrasing questions**

At times, the questions formed a sequence where I initiated the subject, the child responded and I gave feedback on that response (IRF). At other times the question was open ended and gave the child more opportunity to explain their thinking. In examining these types of questions in more detail below I ask whether both were useful in giving me the information I needed in order to form a helpful response?

### *Aspects of Initiation, Response and Feedback (IRF)*

In my review of literature I placed myself alongside Alexander (1997) in feeling that IRF exchanges have a place in pupil learning, but wrote that

there was a need to examine further how and when such exchanges might be useful. Back in 1976, Barnes sounded a note of caution saying that too often teachers read into children's answers what they want to hear rather than what the child really intends. From my study of my discourse with children I conclude that it does not seem to be the use of IRF in itself that is the issue when considering whether it supports learning, but rather how it is used, particularly in the reception of answers by learners, and whether it is appropriate to their moment by moment understanding. As I examine examples of my use below, I question whether my approaches were appropriate.

The first example of the discourse strategy IRF was when I was talking with Jay in one of the individual follow-up conversations designed to explore the issues raised during the transcript analysis of the initial discussion with the same child. We were continuing to think about place-value. He had written numbers as 5251, 40275, 5020, 70500 but read them as 5251, 4275, 5020, 7500. In this situation, I needed to find out something of the exact nature of his grasp of the subject.

I include an excerpt of some length in order to allow the reader an appreciation of how the IRF sequence developed.

Researcher     Yea..ah, that's what I asked you to write. Can you see any difference between those two and those two?

Jay             Um ..... There's no nought at the end or there's no nought there.

Researcher     Which one? There's no nought in that, no, but there is in that one.

Jay             Maybe the end bit.

Researcher     No, you're right. These two were right.

Jay                    So there's a nought at the end.

Researcher        Don't alter them. OK. Just look. Can you see anything different about those two as compared with those two?

Jay                    Those two?

Researcher        Mm.

Jay                    They don't have a five at the beginning?

Researcher        They don't have a five at the beginning. Yes, those two do have fives at the beginning. You're right but those two, that doesn't make too much difference. Now let's try something else. You see each of these figures that are here.

Jay                    Uh hum.

Researcher        We call those digits, part of a number, all right? Would you like to count the number of digits that are in those two compared with those two.

Jay                    Add them all up so that ...

Researcher        Count them. How many digits has that one got?

Jay                    Four

Researcher        How many digits has that one got?

Jay                    Four.

Researcher        How many digits has that one got?

Jay Five

Researcher How many digits has that one got?

Jay Five

Researcher Right, so that's a difference isn't it?

Jay Oh yes.

Researcher As well as the five at the front. OK. Would you like to write, underneath that one and above that one, thousands, hundreds, tens and units?

Jay Thousands, hundreds, tens and units.

Researcher OK

Jay Thousands, hundreds, tens and units.

Researcher Good. Now what about the other two?

Jay You can't really put them in.

Researcher Mmm.

Jay Oh I'm stuck.

Researcher Right. Do you see, that these two. You wrote that, four thousand, two hundred and seventy five, and that is what I asked you to write. Can you now see what you might have done wrong?

Jay I put the zero in.

Researcher    You did, yes.

Jay            So I throw it out.

Researcher    Right.

Jay            There.

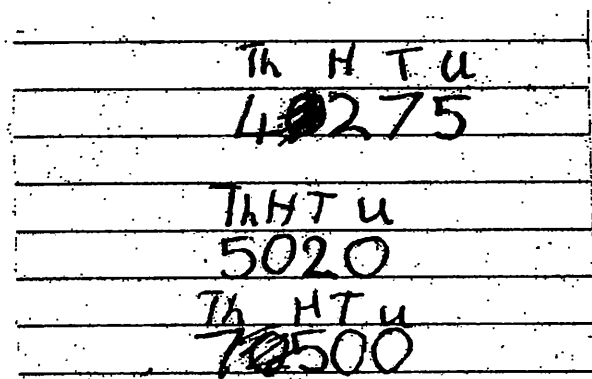


Fig 4.1 Jay's correction of his numbers.

*Jay 22.2.98 pp 2 - 3*

At the beginning of this excerpt I was making Jay guess what I was thinking, using non-specific questioning. This approach was not productive. Sinclair and Coulthard (1975) suggested that can happen when a child does not challenge the teacher, even if they do not understand. There were a range of answers Jay could have given but I wanted a particular one. By moving to very structured closed questioning I caused him to focus on the discrepancy between his written work and his spoken contribution but in the course of that I elicited from him the answers I was seeking. The question has to be asked as to whether this closed IRF sequence aided his understanding in any way. Alexander (1997) says it is possible and I believe it was in this instance. I believe he saw that he did not have a place for the extra zeros. However, I assumed he also gained an understanding of the implications of one digit per place with other numbers. This may or may not be the case, my 'listening' to what he really meant may or may not have

been accurate. We continued talking about place value in a structured IRF format and it seemed that his grasp increased.

Researcher And you get ...

Jay Four thousand ... two hundred ... and er .. seventy five.

Researcher Good. And that would be the same, wouldn't it?

Jay Thousands, hundreds, tens and units.

I wrote the number with forty thousand and read it to Jay. He was then invited to put the column titles above it.

Jay OK um, units?

Researcher Yeah.

Jay tens,

Researcher Yeah.

Jay um thousands.

Researcher Mmmm.

Jay No, that's wrong.

Researcher You can only have one column. ... OK, shall I help you?

Jay Yes.

Researcher That one's thousands, OK, and I said forty thousand.



Jay Oh so that's a ten.

Researcher Ten ... whats?

Jay Ten hun.

Researcher Ten ...

Jay Ten thousand.

Researcher Ten thousand. That's right. So that column is ten thousand.

Jay 22.2.98 pp 3-5

He was then able to read a number with several zeros correctly. The conversation continued to explore place value for some time, allowing Jay to demonstrate his ability with quite a few numbers. Did I adopt the IRF approach because I was unwilling to see his confusion? In this instance, I think it was to keep his focus on complex patterning and not allow him to be diverted by his own confusion. I feel that I did listen and see accurately, at times responding appropriately, and, therefore, used closed questioning to clarify an aspect of place value for him.

Did a similar IRF sequence help Gemma in the following exchanges? Transcript excerpts are given before an attempt at answering this particular question.

Researcher How much bigger is that one than that one?

Gemma Well that is one unit and that is ten.

Researcher Right, so how many times bigger is it?

Gemma Um ..... ten.

Researcher Yes, that's right. OK. Let's do that. How many times bigger is a one in that column than one in that column?

Gemma Well that's in the hundreds and that's only ten now, so the one hundred's bigger than ten.

Researcher It's bigger by ten by how many? ..... How many times?

Gemma One.

Researcher How many times bigger is a one in the hundred's column than a one in the ten's column?

Gemma Ten.

Researcher Ten times bigger than a one in the tens column, all right?

Gemma Yes.

Researcher ..... So how many times bigger is a one in the thousand's column than one in the hundred's column?

Gemma It's ten.

Gemma 19.5.98 pp 10 - 11

She seemed to be grasping the fact that the answer I wanted each time was ten, but it still cannot be proved that she was understanding more about place-value. I was intent on helping her to see the pattern of multiplication by ten but by my setting of the pace and the thrust of the questions I was listening for the response I was expecting. It was not difficult for her, in that circumstance, to guess what I wanted. Maybe she did listen to her own responses and grasp the pattern, maybe not. I should not have assumed she had. Interestingly, my responses were *evaluative*, the word used by Cazden (1998), but it did not rest there. The next question built on my evaluation of

her answer. I assumed she understood up to that point and then posed a further question which was 'contingent', depended on the response she had made in order to move forward a step at a time (Wright 1993).

Later, I wanted to use that information to talk about decimal fractions.

Researcher     How much smaller is that one than that one?

Gemma           Um ..... huh ..... ten.

Researcher     Ten. Yes. So if that's a one, a whole cake. (*I drew a circle and divided it into ten segments.*) How much of the cake would that one be?

Gemma           Um four?

Researcher     Got a whole one. The whole one is there and it's ten times smaller.

Gemma           Um ..... would it be ..... ten?

Researcher     It would be ..... not a ten but a ..... You would have to divide the cake into ten.

Gemma           Er.

Researcher     I'm not doing it properly, like that. So that column is one tenth, one out of ten. Have you done fractions?

Gemma           Yes.

Researcher     Right, so that is one tenth. OK? So if we go to the next column ..... what do you think would be the denominator there?

Gemma Um ..... er ..... one ..... quarter?

Researcher Have another think. How many times smaller is that column going to be than that column?

Gemma Oh, one five.

Gemma 19.5.98 p 14

I was taking large steps in understanding, moving from place value and the division by ten to fractions and then asking for a denominator. It may well not have been the form of questioning that confused Gemma, but the phrasing of the questions themselves. Certainly, I was not listening to her total confusion but seeking to stimulate a right answer, whether she understood or not. In this instance the use of IRF questioning was totally inappropriate, whatever answer Gemma gave, because I needed to find out her thinking on the matter, to listen carefully to her concept of decimal fractions. I did not need to be imposing my agenda and thinking on her. Her understanding was too far removed from mine.

I referred to a discussion on page 47 which illustrated a comment by Flanders (1970) of how a teacher could respond when a pupil broke out of an IRF sequence and I include it here.

Bill I'm really stuck at this one.

Researcher Right, let's give you a little bit of help with it. When you did this one,

Bill Yes

Researcher The first thing you did was .... I gave you a half and you changed it to,

Bill Four eighths.

Researcher     You changed it into eighths. Why did you change it into eighths?

Bill             'cause that one was in eighths.

Bill 5.5.98 p 11.

Bill was then able to use that understanding to add fractions in sixteenths. By not trying to guess what answer I was wanting and admitting his confusion, breaking out of the IRF sequence, he gave me the opportunity to refer him back to previous success. He was able to connect with that and relate it to this new situation.

The IRF sequence tended to be used in my conversations with children when I had made inappropriate demands and needed to increase the support I offered in order to maintain confidence; not the most helpful oral strategy to build on perceived understanding. A reason why it may not be the most helpful strategy is that it relies heavily on the teacher directing the path of thinking. This may help a child grasp a pattern, or rhythm, but the teacher needs to be listening very carefully to the answers and ensuring that they are not the outcome of the child's successful guesses at what the teacher is expecting. My few examples would seem to be in line with the thought that it is not the use of an IRF sequence or not which determines whether it supports learning, but how that sequence is used and whether it relates directly to the moment by moment understanding of the pupils. Calderhead (1984), among others, made that point.

### *Aspects of asking open questions*

If closed IRF sequences have the danger that the child can successfully guess the expected answer, that the teacher, on hearing that answer, asks another contingent upon it and thus misses listening to the actual understanding of the child, does the asking of open questions fare any better? I made reference in the literature review to Wright (1990) who said that by asking questions which provoke reasoning in order to respond the

pupil can be encouraged to hypothesise. Pollard and Tann (1993) specify higher order thinking such as analysing, evaluating and decision making as some of the benefits of asking a question to which there was an infinite variety of possible responses. My concern was that such an invitation to respond in a way personal to the child might not provide sufficient support and could only be used where a child had sufficient understanding upon which to base their thinking and the confidence to use it. As I examine my limited use of the open question some of these issues are highlighted.

It may well be that open ended questioning stimulates a greater degree of learning. The Numeracy Strategy (DfEE 1999b) advocates the use of a variety of questions.

It is easy to use certain types of questions - those that ask the listener to recall and apply facts - more often than those that require a higher level of thinking. If you can use the full range of question types you will find that children begin to give more complex answers in which they explain their thinking.

(DfEE, 1999b, p 4)

Open questions allow the child more freedom of response and thus give the possibility of an opportunity for the adult listener to hear more accurately the state of understanding articulated. Possibly, they also give the child the opportunity to construct understanding whilst they are speaking. However, I made reference in my literature review, and above, to the fact that I felt open questions can, sometimes, be threatening to children. Now I examine my evidence, taken from a variety of discussions about place value; decimal and other fractions calculations, which explored topics being addressed in the children's' classroom, in order to find out exactly in what context I used such open questions and the effect they had. On the surface, few seemed to challenge or deepen thinking (Bonnett 1994), but merely served to help the child explain their ideas. I conclude that it is not so much the open nature of the questions which can cause concern to pupils but the fact that they need to be asked at the point of understanding, provoking a reworking of that

understanding, leading to a deepening of it, thus demanding considerable thought and perception on the part of the teacher.

When talking with Jay about mental calculation in addition I said:

Researcher     Supposing I gave you ..... this number .... um ... four, forty-eight.

Jay             Forty-eight.

Researcher     And I .... gave you ..... this number, twenty seven and I said very quickly without writing anything down. In your head, how would you work that out? (*Jay had been writing the numbers as I spoke.*)

Jay             You would ..... um .. you would get the .... seven and then you would add on the ..... you don't add the seven up and then add seven. I just start from the seven and then I carry it.

Researcher     OK.

Jay 18.2.98 pp 6-7

From this answer I was able to ascertain that he used counting on in addition and that he relied on a traditional algorithm format, even when trying to calculate in his head. It did not extend his thinking but gave me an insight into his strategies upon which to build further discussion. He was not intimidated by the question because the demonstration required was well within his capability.

Hayley was faced with a similar problem, slightly different wording. Instead of, "how would you?" she was faced with, "how are you going to do that?" This subtle difference might well have put more pressure on her because it demanded a demonstration rather than asking for an opinion. She could have answered the first by saying, "I might do ...." which is slightly non-

committal and does not require her to be specific by showing what she means. The second pushed her into working the calculation in front of me. In many ways, this was not an open question because I was expecting a certain type of answer, although she could have responded in a different way from my expectation and still have made a correct response, in her terms.

Hayley            (*Reading*) Would you round these numbers to the nearest ten, hundred, one thousand?

Researcher      OK, how are you going to do that? ..... good, ..... good, ..... good ..... good, ..... very good. You've answered that question, haven't you? You did it all in one, didn't you? Well done, all right, now ..... uuuuum ..... What does the next thing say down there?

Hayley            Use rounding or approximation to calculate this sum.

Researcher      How are you going to approach that?

Hayley            ..... about ..... gonna be ..... over one hundred and fifty.

Researcher      Why do you think that?

Hayley            'cos nine and two is ..... eleven, that's one carry one

Researcher      Ah you're working it out.

(Hayley 9.6.98 p 1)

The question above, with its subtle change of wording, did seek to encourage a challenge (Bonnett 1994) but did not reach Pollard and Tann's (1993) taxonomy for high-level cognitive demand. The question, on the other hand, was well within Hayley's capabilities and subsequent questions



revealed that her approach was much the same as Jay's in using approximation. It did not upset her.

My questioning of Hayley was in the context of my seeking to assess, not extend, her understanding. In other words I was seeking to listen to her in order to access her understanding. At one point, in another conversation, we were looking at some numbers which included decimals and seeking to put them in order:

Hayley           What does one point oh four mean?

Researcher       What do you think it means?

Hayley           Because it's got no tens and it's got four units. That's lower than the rest of them has got.

Researcher       OK. Try the next one .....

Hayley           I think the same.

Researcher       Are they? Why do you think they're the same?

Hayley           Because forty-one point nought is just the same as four hundred and ten.

Researcher       Right, OK, if that's what you think. .... Good. OK. Why do you think we bother to put a point in sometimes?

Hayley           To trick us?

Hayley 5.5.98 pp 3 - 4

Certainly the last of my questions had the potential to extend thinking, even to the point of considering discrepancy, speculating, reasoning; all within Pollard and Tann's (1993) taxonomy, but as I was seeking to find out what

she thought and not lead her in any way the opportunity was not taken further. I listened to her comment which seemed to reveal a total lack of knowledge of decimal fractions and sought to refrain from starting to try to teach her. I refrained. In my restraint, I wonder whether Hayley had been caused to consider the reasons for my questions or re-organise her thinking in any way. Probably not. If I had followed up the last comment she might have revealed greater knowledge than at first demonstrated? Her last comment would lead us to think that she had not encountered decimals before and therefore not connected with present understanding. She had nothing on which to begin constructing answers to my questions. Later in the discussion, this proved not to be the case because when I began to explore her understanding of place value and then led onto the matter of decimal places. She commented, "I did these with my mum, two nights ago." It takes time to construct or apply an understanding. Later in the conversation we did return to tenths and hundredths moving on to the matter of ordering:

Researcher      Why do you think that?

Hayley            'cause it's another decimal. Decimals are lower than whole numbers.

Researcher      Not necessarily, but you are right. It is the next one.

Hayley 5.5.98 p 14

Here there is still some confusion over decimals and not just on Hayley's part. Had I taken time to consider why she thought decimals were lower than whole numbers I might not have confused her by contradicting her. In one major respect she was right, but my thoughts were with the numbers in front of us. A case of faulty listening. However, Hayley had displayed more understanding than her earlier comment, 'to trick us' led me to believe. Had I not asked why I might never have realised that she still held a confusion. Open questioning helped me to gain a slightly better insight into Hayley's

understanding than I might have had otherwise, but I am not sure how much the questions directly helped her thinking.

Bill was faced with ordering fractions:

Researcher     Why do you think that is the smallest?

Bill             I don't know, I just guessed.

Researcher     Right, now, how can we do it without guessing?

Bill 9.6.98 p 2

On the surface these questions might be construed as closed because I could be expecting a certain answer. However, that was not the case. I genuinely was seeking to gain an insight into his thinking. Bill's answer was confused and he was not able to make any headway until I reminded him about common denominators which he had used in the addition of fractions. One more link in his understanding was needed before he could respond to my open questioning. Again, we see the need for the question to be asked at a point where the pupil has sufficient underlying knowledge in order to be able to reconcile the various demands the question makes, empathetic to the individual (Bonnett 1994).

Gemma, on the other hand, was seeking to order decimal fractions. She had selected most of the items and was left with two:

Gemma           That one.

Researcher     Why that one, now?

Gemma           That one's got thirty seven point nine and that one's got nine point seven three and that one's higher than those.

Researcher     You're right. Why is it the highest?

Gemma         Because that one's got thirty-seven and that one's got nine.

Researcher     Exactly.

Gemma 9.11.98 pp 8-9

Gemma had all the necessary understanding in order for her to make sense of the task and explain her thinking, no small thing. She needed to have an understanding of place value, the decimal point and of significant figures, let alone the order of whole numbers. My questions here could be construed as closed because I was hoping for a certain answer, but my motive was open because I wanted her to express things in her way so that I could enter into her approach to dealing with the subject matter. Whatever their status, they did not cause her to employ higher thinking skills.

Gemma and Karen were trying to reconcile their two different answers to the same algorithm:

Karen           I took three away from two.

Researcher     Why did you say that?

Karen           Nn ..... Oh um the two fits under the one but I done it like that, across.

Researcher     You have, yes.

Karen           I done it like the times table.

Researcher     Yes, so what can you do to put it right?

Karen and Gemma 15.3.99 p 10.

In order to compliment a session on problem solving presented by the class teacher, Jamie, Lisa and Rachel worked on the problem of having to fit six digits (1,2,3,4,5,6) into the pattern of a sum:

$$\begin{array}{r} \phantom{x} \quad ? \quad ? \\ x \phantom{00} \underline{\phantom{00} ?} \\ ? \quad ? \quad ? \end{array}$$

Rachel Have to try six.

Jamie Yup ..... forty-six

Rachel Can't have that

Jamie No .....

Rachel Three times five ..... No.

Researcher Right ..... Why couldn't you have forty-six?  
..... (5 sec)

Rachel Mm ..... (7 sec) Forty-six think it might be in the  
thousands

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Again, my challenge to Rachel caused her to stop and think about something to which she had reacted instinctively. She had to spend more time thinking through the problem and constructing a reason which was a necessary activity if this problem was to be solved using strategy. I believe it did move the process of her thinking forward.

The question, “can you explain?” invites an even longer response from pupils as they are expected to uncover their thinking at some length. It does not assume knowledge, as is raised as a concern by Johnson and Gott (1996), but sometimes it seemed to be too vague for the child to respond. It appeared too vague for Hayley to identify a strange move in one of her calculations without more prompting. She had written:

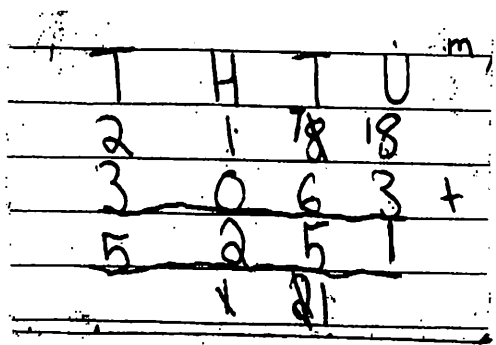


Fig 4.3 Hayley’s calculation of an addition algorithm.

Researcher     You got the right answer there, didn’t you? How did you do that one, can you explain it to me?

Hayley         I ..... I didn’t think you could do adding but I went to the next column, crossed off the eight, put the seven, carried on the ten.

Researcher     Uh hum.

Hayley         Three add eighteen is twenty one carry the two and that’s six add seven is thirteen add two is fifteen, five carry the one, one add one is two and three add two is five.

Researcher     That's interesting ..... got the right answer, can't ... I can see what you've done. What were you getting a little bit confused with when you did that? That carrying across?

Hayley            Oh I was thinking of it as a take away.

Hayley 5.5.98 pp 6-7

Hayley was using a half-formed understanding of addition and subtraction algorithms to approach the problem. I could have left her approach because it did succeed but was unnecessarily unwieldy. Upon reflection, I realised why it was successful but feel that a challenge, albeit rather negative, did cause her to review her thinking. The original question did not.

The examples above are few and some made only a limited contribution to stimulating higher order thinking, if at all. This was probably because some were actually closed questions in the sense that I could anticipate the theme of answer which would be given. They did not provoke reasoned thought. By doing this, I did not present the children with a great deal of insecurity, thus avoiding, for the child, the threatening scenario, which I considered on p 101.

Some of the questions did provoke a response which gave me insights into the child's thinking but the questions which did not readily find a link with the pupil's understanding did not help and may have de-motivated them because they could not answer. Again, the importance of careful listening, beyond the apparent, on the part of the teacher seems to be crucial in the helpful employment of exploratory questions. Teachers need to think through their use of open questions very carefully so that they allow children to use current knowledge in order to construct greater understanding.

**Aspects of listening whilst waiting**

Whilst speaking with Jay in the opening conversation I identified the need to give him more time to think, more time to formulate his response.

Evidence from later discussions is now examined. In some of them I waited intentionally in order to evaluate the outcome. In others the silence occurred naturally. Based on my research evidence in the field of classroom communication I would argue that if children are to be encouraged to construct understanding then they need time and space in which to do so. Rowe (1974), see page 51, conducted an investigation in which she found that the exchanges in a discourse were of a higher quality when the teacher paused for more than three seconds, after asking a question or before responding to a pupil's input. In their study of attitudes towards silence, Jawonski and Sachdev (1998) found that silence "seems to be positively viewed as a facilitative device enabling students to gain access, organise and absorb new material" (p 286). Although not strictly an oral response, I am including pauses, or even prolonged silence, in my brief, because intentional waiting is not passive, it is employed for a purpose. Certainly, Jay felt that my conscious efforts to wait and give him space had helped him. When asked why he had enjoyed the time in which we had worked together he said,

Jay                Two reasons {with me}  
Bill                                {work} together

Jay                Yeah, no three reasons. Um .... get to work together .... we  
..... enjoy doing ..this maths .. because you give us time ....  
and stuff.

Jay and Bill 24.5.99 p 14

One of the instances to which Jay was referring above might have been the following:

Jay                Five sevens is .....



Bill                    We've done it already, Jay.

Researcher        What's five sevens? ..... (9 sec)

Jay                    thirty five?

Bill and Jay 26.4.99 p 22.

Jay, as he rightly said, needs time to think and this requires patience on the part of others, something teachers do not always give because they do not wish to see a child in apparent discomfort. Bill behaved like a teacher by giving a prompt in order to support his friend and in a way that I probably would have behaved had I not been trying to insert pauses into the conversation. I was able to re-establish the pause and Bill co-operated in order to give Jay time to work out his answer. Jay, the quieter child of the pair, was given the time he needed. Collins (1994 pp 317-8) advocates the giving of time to the quiet child in order to allow him/her to construct their response in advance of speech. Had we not done so, Jay might not have succeeded and could have experienced a further dash to his already frail confidence. This happened on another occasion when I did not support children in waiting for their peer and it had a detrimental effect on her:

Lisa                    I haven't done it yet.

Researcher        Sorry about that I'll wait .....

Rachel                One oh nine point five.

Lisa                    Oh oh!

Jamie                Thirty-five

Rachel                A three and not a four

Lisa ..... oooh I can't do it.

Jamie, Lisa and Rachel 14.6.99 pp 13-14.

I accepted Rachel's answer and moved on to the next part of the question totally leaving Lisa without an understanding. The issue of helping pupils give others time is important but one for which I do not have the evidence to explore. It is something for future study.

Giving children time to think may be valuable but on its own may not be totally helpful. On page 53, I raised the question as to whether all pauses were beneficial or whether it was the nature of the surrounding discourse which was a contributory factor to that benefit. Along with Jawonski and Sachdev (1998), I hold the view that pupils can be intimidated by silence and that teachers can find it hard to tolerate, but I have to admit that on one particularly marked occasion, although I wrote of the session in my journal:

Not a good session. I expected too much of the children  
and there were long embarrassing silences. I am  
wondering about the use of silence, 8.3.99

Later examination of the transcript revealed considerable thinking had taken place, as will be shown later when excerpts are examined.

One of the first encounters with a pause in that conversation did seem to support my reaction to the session. During the early stages of my conversation with Bert, Gemma and Karen, Bert gave a right answer which I ignored. The pause following that only served to intensify confusion because they were probably wondering what was wanted if his answer had not satisfied. They just remained silent.

Researcher I'm wondering what might happen to those squares or to those numbers across the top if that number, the last number on the top line ... if supposing the square had seven on the line.

Bert Would be odd

Researcher     It would be an odd number you would think, yes. What might it be? What number might it be? ..... If it was seven across the top ..... there were seven squares.

Bert             Seven

Researcher     ..... What do you think? .....  
Have a look at the squares we've got and the numbers we've got in those squares. .... (10 sec.) What's that number there when you've got .... How many squares?

Bert, Gemma and Karen 8.3.99 pp 1-2

Then we entered a sequence of closed questioning and answering until we arrived again at Bert's answer. I think I did not realise that I had closed down the scope for flexibility in answering and was still wanting a much more detailed explanation. Here was an instance where I did not listen carefully, too set on my own agenda.

Not only does pausing help the pupil but it also has benefits for the teacher. I referred on page 52 to the claims of Tobin (1986) that after a pause teachers tended to ask questions which caused pupils to engage in higher cognitive activity in order to answer, possibly because the teacher had had time to formulate their question and make it more appropriate. Although, in the following example, part of the conversation referred to above, I do not specifically ask a question following a pause the slow pace did give me time to assimilate what the children were saying, time to listen and comprehend. As part of our consideration of pattern in number we were talking about rectangular numbers and whether they could be odd and even. At first, I was genuinely not sure.

Researcher     I wonder whether rectangular numbers are odd or even or sometimes one, sometimes the other.

Karen           Even and odd?

Researcher     You think they're even and odd, Karen ..... I wonder what rectangular numbers are ..... are they odd or even?

Karen           ..... (3 sec) They're odd I think.

Bert             I've got an even though.

Researcher     You've got an even.

Bert             'cause three and four across.

Researcher     ..... Mm ..... Shall we think if we can think of any odds? I wonder if there might be ..... (10 sec) something to think about isn't it?

Gemma          They wouldn't be like two times two, three times three 'ud be like four times three or something like that, four times five.

Karen           Yes

Gemma          One two times three ..... they just be like four times three or.

Bert             Odd times an even.

Gemma          Odd times an even.

Researcher     Um .. um when you've got an odd times an even does it end up as an odd or even, I wonder? ..... (7 sec)

Gemma          Even?

Bert, Gemma and Karen 8.3.99 pp 16-17

We proceeded to decide that they could be both. I feel this sequence shows that not only do the children need thinking time but the adult does too if

they are to make truly helpful responses. In this case, the adult interactions were to keep the conversation going and directed without giving definitive answers. It matched the “cognitive processing ability of the students” (Tobin 1986).

Interestingly, Rowe (1974) said that where there were longer pauses teachers tended to repeat the words of the children less often and I guess one of the reasons for repetition in a short pause conversation might be to buy time, to give teachers thinking space. Here, however, I repeated words along with the pauses because I felt the need to support without giving a lead. I wanted to demonstrate acceptance of the children’s contributions and keep the conversation going.

The discourse discussed above showed that progress could be made in thinking and that the pauses in the conversation could have contributed to the process of building understanding. This is in line with Rowe’s findings that interactions were of a more complex nature when there were pauses for reflection.

Later in the same session, we were discussing triangular numbers and what happened when you added two consecutive ones together. We added a few and then I asked:

Researcher     Have you met those numbers somewhere before?

..... (10 sec)

Gemma        Yeah

Researcher     Where have we met them before?

Karen          Um square number?

Gemma        Square numbers.

Researcher ..... ah ... so two triangular numbers next door to each other ..... seem to add up to a square number ..... (3 sec)  
I wonder if that's always true ..... (9 sec).

Bert, Gemma and Karen 8.3.99 pp 22-23

The answer following the first pause resulted in the response for which I was hoping. The second required thought at a deeper level such as asking, "How do I find out?" My intent was to give the children time to process the question but they did not answer and needed extra support before we achieved the objective because they did not have enough strategies to cope. I had not used my time so effectively and made an inappropriate demand on them. I had not established their present understanding through listening to them with sufficient a degree of accuracy to be helpful in the informing of my next input. In answer to Cazden's (1988) point about waiting in order to give a child time to think, I would say that just a pause is not enough. It has to be appropriate, in terms of giving space for the constructing of a response, but not allowing a child to be embarrassed by having attention focused on their lack of ability to respond, if this oral device is to contribute to enhancing learning.

In the following instance the lack of intervention on the part of the adult seemed be beneficial in allowing children to develop their thinking. Gemma had been describing a calculation and then Bert evaluated it:

Gemma Um, you set it out, you put thousands, hundreds, tens and units and tenths.

Karen Mm.

Gemma Then we put six in the thousands; nine in the hundreds; four in the tens; three in the units and nought in the tenths because of the decimal point. And then because it is eight hundred you put eight in the hundreds; six in the tens; five in the units and point two. Then you can't do nought take away

two so you borrow from the three, that leaves a two, that makes ten, ten take away two leaves eight.

Karen Mm.

Gemma You can't do two take away five so you borrow from the four, change that to three and put a one, so it equals twelve. Twelve take away five is seven.

Karen Mm.

Gemma Then you do, you can't take away three from six so you borrow from the nine and that comes to eight and move ten to thirteen, take away six. That equals seven, eight take away eight. That equals nothing, and then six take away six, nothing.

Bert If you cross off nought (*indistinct*) put on the bottom line how's it come to eight? (*it came to thirteen in Gemma's explanation*) ..... (11 sec)

Researcher It's a good point.

Bert I made it six eight two seven point eight.

Researcher Six eight two seven point eight. Ho, what did you do there, Bert?

Bert I done the same but when you had to cross out the four put a three put a one it comes out as thirteen.

Researcher Yes.

Bert Thirteen take away six.

Researcher Yes.

Bert Yes ..... ah

Researcher See?

Bert Yes I was getting it wrong I was.

Bert, Gemma and Karen 8.3.99 pp 32-33

In this instance, the pause seemed to give me time to think, to comprehend what he was saying and to hold back from correcting him which might not have helped him see his mistake. By further prompts he worked it out for himself. There are times when pupils can be left to work out a problem and other times when they should be given the solution, but the issue for the teacher is knowing when. Perhaps if the teacher uses the moment of silence to reflect on the demand from the pupil's point of view the 'when' might become somewhat clearer and the teacher can then 'scaffold', in the sense used by Mercer (1995), see footnote 1 after section 5. A scaffold which gives little support or access to the building already in place is of scarce value. The teacher has to ensure their contributions to the conversation are appropriate to the need.

I raised the question as to whether giving extra time to think is universally helpful. I suggest, the answer has to be, 'no' because if the teacher is not giving a prompt within the current understanding of the children then those children are left with nothing on which to work and will find the silence oppressive. Here was an instance where the question I gave was also obscure and did not help the children. Therefore, the silence did not contribute to the construction of understanding. Lisa had successfully demonstrated the working out of a subtraction algorithm. I wanted the children to understand the process taking place during decomposition.

Researcher You were able to tell us how to work it out, can you explain why that works? .... what is happening with the actual



numbers? ..... or anybody can you tell us why what you did there is the right thing to do? ..... (5 sec) Any idea? ..... Shall we see if we can do it together?

Jamie            Oky Doky.

Jamie, Lisa and Rachel 14.6.99 p 5.

I tried several times, always asking questions which invited a lengthy response. In this instance it might have been better to have asked why she had crossed out a digit and added ten to another one before inviting a fuller response. The children would then have known to what I was actually referring. The status of the question, not the following pause, as is suggested by Wood (1992) was the crucial aspect of this exchange. From this, there seems a fine balance between whether a silence is helpful to the situation or not and that balance involves the 'listening', the establishing of current pupil understanding by the adult.

The example below does seem to be somewhat more helpful in clarifying the point at which Bill's understanding needed some support. He appeared to know what I was asking because he made an immediate correct response to the question, admitting it to be a guess, but hit a problem with his ordering of fractions having varying denominators.

Researcher    What I asked was if you could think up a way of proving which is the smallest .... and it's not so difficult. You did something similar the last time I spoke to you ..... (4 sec)

Bill            Huh.

Researcher    I was surprised you could do it but you did, you were very good.

Bill ..... (7 sec) did I put them all in the same fraction?

Researcher You did. you're on the right lines, well done.

Bill (*indistinct*) the right answer. .... (16 sec) two er  
..... (9 sec) one and one eighth ..... (8 sec)  
hrrr ..... (6 sec) hrrr ..... (6 sec) hrrr  
..... (4 sec) tch tch tch ..... (10 sec)  
hrrr ..... (8 sec) um.

Researcher What's the snag? ..... have you hit a snag?

Bill I don't know how many tenths one and one eighth is.

Bill 9.6.98 pp 2-3.

On the surface, such a wait seemed unproductive. Bill was not solving his dilemma but it did give him the space to formulate his problem, an act of listening highlighted by Wood (1992), and I was soon able to ask him to give me a number of which ten and eight were factors. He was then able to complete the task. Note also that I was dealing with an able child and willing to give him over a minute. I was not so patient with less able students because I felt they needed more frequent support, a failing of teachers discussed by Rowe (1974) who said that it was to give more reward for effort (p 208).

When I reflected on my waiting with another group of children they commented that they thought it had been 'quite cool' but did prefer a teacher in the classroom situation to tell them what to do rather than waiting for them to work it out:

Jamie I'd rather them tell me what to do.

Lisa Yes.

Researcher      Why do you think that?

Lisa              'cause if they don't then you might get stuck and you wouldn't be able to do the sum.

Rachel           And you might get told off.

Later I went further in my questioning on this point:

Researcher      What about the way I did it? Did it stop you understanding it?

Jamie            No because we're in a group and we can all work together.

Jamie, Lisa and Rachel 12.7.99 pp 4-5.

My brief exploration of 'wait time' leads me to feel that giving pupils the time to formulate their understanding, even at a very factual level, affords them the opportunity to succeed and thus to boost confidence, as found by Collins (1996). However, that will not happen if the context of the pause is not clear or if it is not appropriate to pupils' prior level of understanding. In fact pausing might even be detrimental, as Jawonski and Sachdev (1998) point out, because it might cause awkwardness which makes the experience of seeking to understand mathematics less enjoyable than it might otherwise have been. This in turn harms motivation, an important aspect of learning. A slow pace to the conversation can help teachers to think about what they are saying; to assess pupil understanding and thus to phase their contributions in response to pupil need (Mercer 1995). It can also help the teacher to reflect on what is being said and refrain from responding so that pupils have time to evaluate their own work. All contribute to the oral building of understanding, part of my research question.

### **Aspects of speculation in the teaching situation**

In the section above I gave the example of a conversation about square numbers where I was intentionally seeking to wait (Bert, Karen and Gemma

8.3.99). Upon examining the transcript I also realised that I had used speculation, rather than direct questioning and this caused me to wonder whether such an oral approach might be helpful in establishing and enhancing learning as well. I proceeded to intentionally incorporate such a device into conversations and examine transcripts for the effect.

It has been suggested by researchers (e.g. Wood, 1992) that if teachers approach discussions with pupils in the form of speculation they encourage more “active and cognitively engaged roles” (Hughes and Westgate 1998 p 174) on the part of learners. The learners are encouraged not to look upon the teacher as the “authority” whose answers they need to discover, but as a co-worker, a participant in the endeavours of making sense of their present environment. In a preceding section about open questioning, I discussed the value of stimulating reasoning, higher-order thinking, which is helpful in the construction of concepts. A speculating teacher models just such behaviour and encourages a collaborative approach, one of the questions raised by my initial conversation with Jay. With this in mind, I set about trying to speculate for a variety of purposes, to stimulate a demonstration of understanding or ability; to encourage thought about what was observed and why; to help children predict and to support them when they were moving into error. One of the conclusions I reached was that, if I made an intervention which was not totally in keeping with pupil thinking, speculation gave them the freedom to pursue that thinking along lines independent of me. However, appropriate interventions can help to develop pupil understanding without directing, as can be seen in the first section below.

This conversation took place before the one which stimulated me to think of speculation as a strategy but it was as I examined the transcript that I realised I had used the strategy unintentionally. We were investigating the patterning of number in two squares ( see Appendix 1), a topic chosen to compliment exploratory maths taking place in the classroom.

Karen            If this went on down it would go four, five, six, seven, eight, nine, ten.

Researcher    Oh that's interesting ..... I wonder why it does that.

Gemma        ..... 'cos they're odd?

Karen        And even

Researcher    I wonder if there's some other reason .....

I felt that the first line of thinking on which the children embarked was not going to lead very far so tried to extend the ideas. Gemma responded with another observation about numbers arranged diagonally:

Gemma        On that one it keeps, it keeps. That if it say six that's one place forward, so six, one place forward, seven, it's one place forward.

Karen        Oh yes

Gemma        Keep on doing that one place forward, then two places f-forward, three places forward.

Researcher    That's good. That's interesting. .... I wonder why it does that.

Gemma        ..... down the side it's

Gemma and Karen    (*indistinct*)

Researcher    Yes, you've got you five times table. So I wonder what happens in this.

Bert Four times table.

Karen No it isn't.

Bert Yes it is.

Gemma Four, eight, twelve, sixteen.

Researcher Ahh.

Karen I should have done that one (*indistinct*) times table.

Researcher ..... So you've got your four times table there, five times table there ..... I wonder if we could do another square where we would get our six times table at the end.

Karen Yes

Researcher And what would it look like?

Bert It would go up to six there.

Bert, Gemma and Karen 1.3.99 pp 29-30

My suppositions, rather than asking direct questions, met with limited response but they seemed to give the children permission to change the subject if they did not want to face up to the challenge, and this they did. They found another pattern to talk about. I followed their focus and sought a prediction, still without a direct question. I was beginning to perform as Chazan and Ball (1999) suggest, steering the conversation, shaping the discussion without completely leading - 'scaffolding' as Mercer (1995) would term it.

The conversation proceeded in like vein with the children finding patterns and me supporting their exploration. However, I did not challenge them to find out why the patterns were there. I was not extending them with contingency questioning, as described by Eisner (1991), possibly an opportunity lost.

Gemma        It's a seven, thirteen it goes up to. .... That'll be three.

Researcher    Yup

Gemma        It keeps on if you go diagonal it will do that.

Researcher    I wonder what happens when you go diagonal? ..... How about having a look and seeing?

Gemma        It stays the same on number, on the first number is one. Then it's six, move it one.

Researcher    What happens when you go diagonal?

Karen        Miss, Miss. I just found out! Look, if it goes down it's six, twelve, eighteen, twenty four. That's the six times table downwards.

Researcher    So it is. So it is. I wonder if something happens in this one.

Karen        An' then four eight twelve sixteen.

Researcher    Oh yes.

Bert        And that, there is the five times table.

Karen            Six, four. Five, four.

Researcher      Oh yes. That's good isn't it? ..... Where else have we got a pattern, got a table like that? ..... I wonder.

Gemma           ..... Here.

Bert             That's not all. Is it?

Gemma           Yes it is, three, skip a number, nine.

Karen            No

Researcher      Fifteen in the three times table.

Karen            Yes, three, nine, fifteen.

Gemma           Three, skip it, nine, skip it, fifteen.

Researcher      Oh

Gemma           Three times table, but

Bert, Gemma and Karen 1.3.99 pp 32-33.

In subsequent conversations I, consciously, set about introducing speculative comment. I was discussing the same squares with Bill and Jay and my comment caused a change in the discussion. The boys had found a pattern which I had not anticipated but they were becoming satisfied with just finding more examples so I called for prediction as to what might happen and this was picked up upon by Bill. Had I told them to move on I might have created some resistance because it meant leaving their moment of triumph. They could have ignored a suggestion but, given the choice, they decided to accept it.



**Jay**                      **What's that one?**

Bill                      Twenty, twenty-three

**Researcher      Twenty-three**

Bill                      Yes, thirteen

**Jay**                      **Yes**

**Researcher** Right, I wonder if it will work for other squares.

**Bill**                    **OK. Shall we do**

Jay                    Maybe if we do ..... Oh. Maybe {if we do}

Researcher {You started} doing the  
seven square. That seven one didn't we?

Bill Yes. This side we said it would go down in .... how many that was five, six, seven.

Jay            One, two, three, four, ... five, six.

**Bill**                      **Eight.**

**Bill and Jay** (muttering)

Researcher    Are you right? ..... I wonder how you could work it out  
whether you're right or not. ....

**Bill** Um ..... (12 sec.)

Jay      One, two, three, four, one, two, three, four, five .....

Bill Five, six, seven, eight.

Jay Six, seven, eight, nine, ten. ....

Bill Oh, look!

Jay Oh ..... arrr mmm ..... four  
add one, five ..... fourteen.

Bill and Jay 19.4.99 p 6

My inept intervention, although it was speculative, took their thoughts away from the purpose of their task and onto something totally different. It appeared to mean that they had to change their train of thought. The demand this subsequent processing of thought made on them at that stage was too great. Instead of ignoring me they sought to respond and lost momentum. It was Jay who decided to return to their agenda and before long they had spotted an instance of their pattern in the new square. Here, the children's discovery, and my steering to extend it, could have been lost by the inept intervention. However, it was possibly due to the speculative nature of that intervention that eventually it was disregarded.

Sometime later in the same conversation Bill responded to speculation with speculation, as Wood (1992) writes can happen.

Researcher I wonder if we could work out without drawing all the squares what the last number might be.

Bill Err, I would guess if it was six across, six times.

Jay Four, what's six times four?

Bill Twenty four it'd be.

Researcher It would be .....

Bill No it wouldn't be would it?

Jay If it was six across.

Bill Six times six.

Jay Six times six?

Bill Yes

Jay Um

Bill Thirty six it would be.

Jay Yes.

Bill And then the next one might end with a five because that'd be six, five.

Researcher So that's

Bill That's be thirty six.

Researcher Right, so what's the sevens one going to be?

Bill Seven times seven is forty nine.

Bill and Jay - 19.4.99 p 12-13.

My direct question, rather than a speculation, was asked at the point where I felt Bill's understanding of the squares producing square numbers was secure and, therefore was appropriate to the situation. It was just used as a check. I feel I had 'listened' to the import of the discussion and sensed that it was appropriate to be more direct.

Again, there is reason to think that my speculation might have helped Bill and Jay in the following extract because the children responded with equally exploratory comments which gave them a way forward. However, help still cannot be claimed with any degree of certainty. In the session prior to the one in which this discussion took place, as a response to current concerns, we discussed the probability of getting a three when throwing a standard die. The boys had decided it was one out of six. In this session, I began by recapping, referring them to the probability scale, nought to one, and seeking to encourage them to work out the decimal place along the scale for a 1:6 chance.

Researcher     OK. and then we went on to say, "How far along that line might it be?" Aaand you said, "About ..... nought point two or nought point three." and I was just wondering whether it would be possible to work out exactly where it would be.  
.....

Jay               ..... cuh huh, cuh huh. If we had a line it would be easy.

Bill               Errrr ..... well we don't have a ruler, do we?

Researcher     We don't have a ruler but first of all you would need to work out, I'm interested in whether it's nought point one, nought point two, nought point three, nought point four or five than exactly along that line. We'll go and get a ruler afterwards to work out exactly along that line.

Bill               What we really just estimating

Researcher     You were estimating last week, and I'm just wondering whether

Jay               We know

Researcher     One sixth, we could work out whether it was nought point two or nought point three, or what it might be. ....

Bill             Two ..... well if we divided .... ten .... by .... uuu .... ten by .... we would have to divide by six wouldn't it?

Researcher     Uh huh

Bill             Ten by .....

Jay              You can't

Researcher     Can't you?

Jay              Then (*indistinct*)

Bill              ..... um ..... Well might go into decimals

Researcher     ..... Well that's not the end of the world is it? .....

Bill              OK

Bill and Jay 24.5.99 pp 1-2.

I made some speculative comments but on the whole I was much too dictatorial, still playing to my agenda. At one point I said, "you" instead of "we" which, according Rowland (1999), is significant. I was directing, not collaborating at that point, and the whole thrust of speculation is to remain co-operative. Had I really allowed the children to think things through for themselves they might have worked out one sixth in decimals more rapidly than they did because they got confused by calculating a third first and then trying to double it, so arriving at 0.6666r. I should have behaved in a manner similar to the teacher quoted by Moyles (1997) who waited for success before challenging in order to encourage understanding. I was able

to use the probability scale to point out the error of that thinking and eventually they did calculate 0.1666r along the scale:

Bill                    One sixth of one.

Researcher        Of one.

Bill                    Yes so ..... divide one by six do I?

Researcher        So divide it by six ..... OK.

Bill                    OK

Bill and Jay 24.5.99 p 10.

The tenacity required to think it through for so long may well have been encouraged by the initial tone of the problem as it was posed. On the other hand it could have been as a result of my persistence that we addressed the problem, nothing to do with the speculative manner.

In the following extract supposition was used to try to prevent erroneous thinking, to break a seeming impasse in a debate between two children. Maybe they would have eventually seen what was needed, but the interjection, in the form of a suggestion, not a directive, did not seem to break their command of the situation. They still owned the process. The class had moved on to calculation using decimals. We took up the theme.

Faced with the sum  $6943 - 865.2$  Rachel had written:

$$\begin{array}{r} 8\ 6\ 5\ .\ 2 \\ \underline{6\ 9\ 4\ \ \ 3} \end{array}$$

Fig 4.4 Rachel’s attempt at setting out a subtraction algorithm.



Researcher Right, good girl.

Jamie Six thousand

Rachel I get it.

Jamie, Rachel and Lisa 14.6.99 pp 30-31

Work continued with very few interventions from me except to support a right move and eventually Rachel produced a diagram like this:

$$\begin{array}{r} 8320.0 \\ - 8652.0 \\ \hline 6077.8 \end{array}$$

Fig 4.5 The corrected subtraction algorithm.

My supposition that something might break the deadlock if the numbers were read out eventually led the children to realise that they had to give the correct values to the digits. The intervention did seem to help them with that when previously they were discussing a mistaken proposition.

This incident seems to indicate that supposition can be helpful particularly in the circumstance where children are reaching an impasse due to a misconception. By providing a new idea without being prescriptive the teacher allows the children to retain control of their thinking without the need for negative feedback. In other circumstances, the success of such supposition seemed to depend on the appropriateness of the intervention. If the call for a prediction was well within the current line of thinking for the children it could be helpful, but where the demands made by that intervention were too great they either floundered or ignored it. Maybe that



is the advantage of speculation. It is not always possible for the teacher to give totally appropriate prompts, a point made by Moyles (1997). They may have a reasonable understanding of the thinking of a child but each child is an individual. At times the developing process of their thinking may diverge from that of the teacher. By couching the prompt in the form of supposition rather than a command the child can ignore it if it is not appropriate to their thinking without any loss of authority on the part of the teacher who has tacitly given them permission to direct their own thinking. This does not mean that the teacher is excused 'listening' because there might be the occasion when a more direct intervention is preferable to a speculative one, as was illustrated in the conversation with Bill and Jay about square numbers. However, speculation can be helpful if the discerning of exact understanding is difficult or if such a non-directive intervention prompts a change of direction or a development in thinking.

The question I have been investigating was how teacher-pupil communication could establish and enhance learning and during this last section I have considered four aspects of discourse. I conclude that it is not so much *whether* one uses a particular strategy, but *how* one uses it that is the vital factor in contributing to the deepening of understanding. The 'how' involves a discerning, on the part of the teacher, of the thought processes and understanding of those with whom they are working. Whatever strategy is used this seems to be the over-riding factor.

## **Approaches to the Mathematics**

### **Situated Cognition**

During my first discussion with Jay, I lapsed into using the illustration of money to try to help him understand how to work out the number of eights in a hundred. Reflection on the transcript caused me to ask whether it was not just the discourse strategy which was helpful, or otherwise, in enhancing understanding but whether it might be the way in which the situation was presented, the vocabulary and concepts used in oral discourse, which affected moment by moment understanding. Did the presentation of

concepts in the form of 'real-life' problems help the thinking process? This is a question I set out to examine in this section.

On pages 25 to 34, I discussed the role of mathematics set in the form of real-life problems or contexts and whether this aided or hindered understanding of calculations. Alongside Cooper (1998), I feel such settings can hinder the learning of mathematical concepts. Resnick (1989) and Pimm (1995) say that linguistic interpretation adds complexity to a problem. A child, seeking to construct an understanding of a mathematical concept, does not need to be trying to understand the linguistic setting at the same time. I agree, and one of the main points raised by my work was that the some children seemed to be diverted from thinking about the mathematics involved onto thinking about other matters related to the context. I cited two children with whom I had spoken, Karen and Jay, and here I examine the conversations in more detail. I had intentionally set the problems, about which we spoke, in a context in order to pick up my earlier concern with the use of situations to aid the understanding of the mathematics, but took them out of the field of the use of money in order to widen the context. We were also approximating, an aspect used by Jay in the first conversation. The context used was likely to be familiar, certainly to Jay, and possibly to all the children with whom it was discussed. Jay found himself diverted by the Sea Life Centre context when we were approximating to the number 347, as illustrated below:

Jay                    It's got to be nearer, say three hundred and twenty-nine.

Researcher        OK, if that's what you think.

Jay                    Three hundred and twenty-nine.

Researcher        Why do you think three hundred and twenty-nine?

Jay                    'cos I don't think seahorses would really be that much in a tank because seahorses do breed a lot. I don't think the Sea

It could have been that this comment was just the result of my inept use of that particular context or it could have been the fact that a situation was being used in which to couch the mathematical problem that caused such a reply. It was inappropriate as far as I was concerned but not for Jay. Cooper and Dunne (2000) make the point about relevance for the pupil, something I forgot and suspect I am not alone in so doing. If we had been standing by the tanks with a good reason for wanting to know how many seahorses were inside and I had chosen more appropriate numbers, making the calculation authentic (Brown, Collins and Duguid 1989), Jay might have then been able to appreciate the need for an approximate calculation.

Jay, again, was diverted by the situation under discussion when we were talking about probability, a subject I approached with him and his friend Bill when they were working in that area during their class lessons. One example was of the frequency of birthday if a baby was born on the twenty-ninth of February. Bill was busy calculating those odds against another scenario, but Jay's concerns were elsewhere:

**Researcher** So which of the two is the best odds?

**Bill**                    **Definitely that one.**

**Researcher** That one, and what about you having a flight in an aeroplane this year?

**Jay** Can I just say something about the baby one?

**Researcher**      **Yes**

Jay But it would only have a birthday every fourth {year.}

Bill {I know}.....

Researcher Mmmm

Jay Well that is so horrible.

Bill So when they are sixteen, they're only four.

Jay Her her her.

Researcher There are people like that, born on February the twenty-ninth. ....

Jay Are there?

Researcher Yes

Jay Why don't they have it like um being born on .....

Bill We'll have more chance of a flight in an aeroplane this year.

Jay What March the?

Researcher Yes what they usually do is they celebrate their birthday either on the twenty-eighth of February or March the first .....

Jay That's not really fair.

Researcher Right what's the chance of you having a flight in an aeroplane this year?

Jay Flight in an aeroplane.

Researcher Do you know what your holiday plans are?

Jay                    Yes, I might be going to Canada, well I want to but .....  
well anybody could go on a flight in a year anytime so it is  
like even.

Bill and Jay 17.5.99 pp 13-15.

After that he was able to make appropriate comments, even to the extent of saying that evens could be presented as zero point five on the probability scale. This was a much more realistic scenario for the setting of a school discussion than the one about fish. Many children do talk about birthdays so although Jay was momentarily distracted he was able to deal with the related mathematical concepts as well. It may be that where children grapple with problems set in real situations, as advocated by Brown, Collins and Duguid (1989), they can calculate answers beyond their capacity to do so when imagining those same situations. The oft-quoted example of South American juvenile market traders who can calculate complicated problems in their heads without ever putting pen to paper (Carraher, Carraher & Schliemann 1985), may have prompted exploration of that thought.

Karen was also diverted from the mathematics during the questions about the Sea Life Centre. I was seeking to find a context in which it would be sensible to make an estimate of numbers because counting was problematic.

Researcher        The sharks swim around and it is difficult always to count  
them, you see, so the ... class when they were counting .... got  
ninety-eight. So about how many sharks do you think were in  
the tank?

Karen                Mmmmm ..... a hundred.

Researcher        You think there were a hundred. .... Why do you think a  
hundred?

Karen            There are loads of sharks in there 'cause nobody likes sharks because they eat dolphins and fish and stuff."

Karen 12.5.98. p 2.

Later, still approximating the number of fish in tanks, I posed the number of one thousand and sixty-two to which she replied, "a hundred." Her reason for giving that number was as follows:

Karen            If they have loads of fish at the Sea Life Centre and yet there are fishes in the sea. Do they catch fishes off the sea?

Karen 12.5.98 p 4.

As an aside, if I had accepted her first answer to the approximation question without probing further I would have assumed she understood the concept which, from this later example, she clearly did not.

Although I had used the context of a familiar place to the child in order to give reality to the idea of approximation her reasoning had little to do with the mathematics involved. When the same problem was posed in a mathematical setting she demonstrated that she was able to respond to the task in the way I had anticipated. I asked her to round one thousand and sixty-three to the nearest thousand without giving any context and her reply was a thousand and sixty.

Researcher      That's to the nearest ten. ... That's good rounding, no problems with that, but that's to the nearest ten, do you see? Look ... if I draw a line.

It was an open line and we discussed whether she had seen one before.

Researcher      One thousand and sixty-three would be ... can you put it on the line?

Karen            Sixty-three will be, ..... what on this bit here?

Researcher Well would it go in that bit? ..... Why wouldn't it go in that bit?

Karen That's ... if you put the sixty-three in there it would be a hundred and sixty three but we want it in there.

Researcher We want to put it, it's more than a thousand isn't it?

Karen Yes.

Researcher But it's less than one thousand one hundred because there's nothing in the hundreds column. [*We had already discussed that and drawn a diagram.*] So it's got to be somewhere between there, hasn't it?

Karen Mm

Researcher Between one thousand and one thous, one thousand one hundred.

Karen Mm.

Researcher How far along the line might it be?

Karen ..... Four.

Researcher You can put a dot where you think it might go. (*Karen inserts a dot*) ..... Why do you think it might go there?

Karen Because if it, it's near the line and if it's going up to a hundred, um sixty three is um near the hundred.

Karen 30.6.98 pp 4-5.

The resulting diagram looked like this:

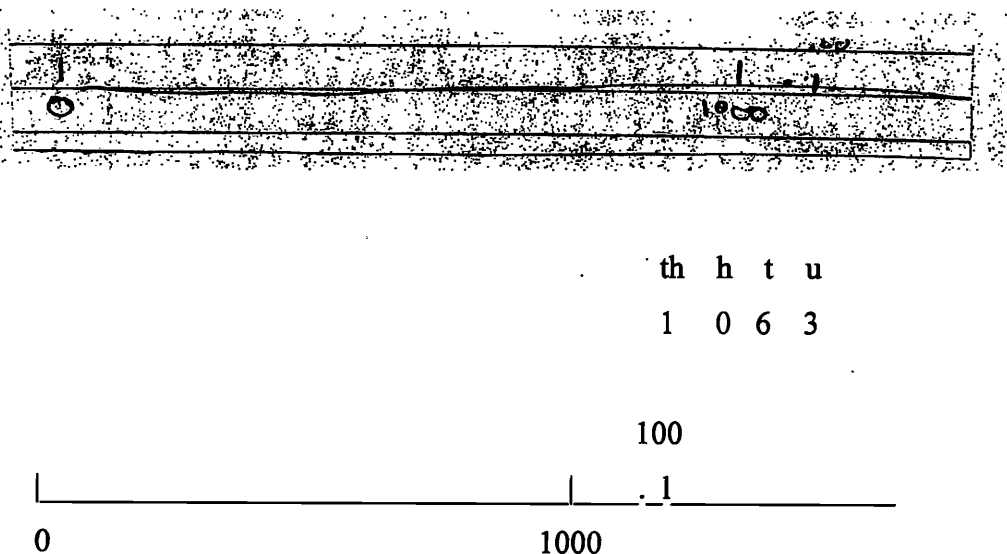


Fig 4.6 Hayley's use of the number line in approximation.

Whilst I had been very dictatorial, almost telling her where to place the dot, she did so appropriately and her final comment was far more relevant to my mathematical expectations than during the conversations in the context of the Sea Life Centre. Of such conversations von Glasersfeld has this to say:

If mathematical symbols have to be interpreted in terms of mental operations, the teacher's task is to stimulate and prod the student's mind to operate mathematically.

Sensory-motor material, graphic representations, and talk can provide occasions for the abstraction of mathematical operations, but they cannot convey them ready-made to the student.

(von Glasersfeld, 1994, p 6)

His point about the need for teacher intervention is supported by Miles and Miles (1992) and Pimm (1995). I would concur, based, partly, on my experience exemplified in the discourse above and from my reading of the experiences of the writers quoted. The point is here made that maybe the diagram was the more appropriate vehicle to support Karen's understanding than a hypothetical situation.



On a later occasion, I returned to the use of money as a vehicle for problem-solving and helping children to set their thinking into context. Three children clearly used their knowledge of mathematical calculations to help them decide how to solve a written problem. They worked on the assumption that the authors of school text-books set up problems so that there are neat answers to the calculations. This was an erroneous assumption to make, everyday life does not always work out neatly, but it has to be said there was justification for their thinking, a point discussed by Pimm (1995). In this instance, however, such past experience diverted the children from paying attention to comprehending the problem as set. It added complication, as pointed out by Resnick (1989). The question was, "Three tickets to go into the Kennedy Space Center at \$21.25 each would cost \$.....". The conversation went as follows:

Jamie            Twenty-one, point twenty-five, times three .....  
twenty-one.

Researcher    You know what you're doing, Jamie?

Jamie            ..... er times sum.

Lisa            No a divide.

Rachel        A divide.

Researcher    Why divide?

Jamie            er ... no times.

Lisa            Divide

Jamie and Rachel    Times.

Lisa            ..... Nar.

Rachel Two times three.

The discussion veered off the subject but then:

Lisa It's a divide sum ..... because you've got to divide it between that, got to divide twenty-one twenty-five cents between three.

Jamie Three people ..... two threes are six there you go

Lisa Yeah.

Jamie Sixty-three dollars point seventy-five.

And so the conversation went on with Lisa maintaining the need for a division sum even though Jamie had the answer until Rachel said:

Rachel Could divide it could divide it and see if it works out there.  
(and then after some comments about cutting hair) threes into twenty-one ..... seven ..... threes into twenty-five ..... eight remainder one.

Researcher So.

Jamie Which is wro-ong.

Researcher So which one is right, dividing or multiplying?

Jamie Times.

Rachel Multiplying.

Lisa Yep, I reckon.

Researcher And why?

Rachel Because it wouldn't cost

Jamie Because if it wouldn't

Rachel Have seven pounds

Jamie Seven pounds um seven dollars and eight cents and a half.

Lisa The cents or something, that remainder.

Rachel It wouldn't cost that much.

Lisa Yeah.

Rachel It would be a little bit dearer than that.

Lisa Yeah.

Researcher But supposing I'd written down there twenty-one dollars  
twenty-four cents instead of twenty-five ..... um.

Jamie Might be a divide.

Researcher Then should it be dividing or should it be multiplying?

Jamie Dividing I reckon.

Researcher Why?

Rachel Might be a dividing then because it's got even two even.  
Jamie, Lisa and Rachel 28.6.99 pp 36, 37, 39, 40, 41.

The discussion proceeded until I drew their attention to the word "each" and

pointed out that to go in each one of them would need a ticket. They had to write \$21.25 down three times before they were convinced. Possibly because of the protracted discussion they had forgotten about the original question, but the point remains that for a long time it was not the situation but previous experience of questions in mathematics which drove their thinking. In the end, it was the visual representation of the numbers which helped (Resnick 1989). Faced with the same problem Bill and Jay did not deviate from multiplication but treated the sum mathematically first and added the context afterwards:

Bill ..... Just times that by three.

Jay ..... Yes .....

Bill Say two one two five.

Jay Two one two five ..... OK. Is it times?

Bill Yes five times three.

They completed the calculation before I said:

Researcher So ..... what do they cost?

Jay Six, sixty-three thousand five

Bill Or dollars or whatever.

Bill and Jay 26.4.99 pp 16-17.

They multiplied straight away, seeing it as a numerical sum first and then adding the context. The context helped them know what sum to undertake, rightly so, but did not help them with the calculation. They had to know how to do that first.

Although, in these later examples, children found the right answer to the question, I would still maintain that without being in the actual context mathematics problems become abstract in a school lesson and that the emphasis should be on the operation of symbols and the identification of pattern. Once children have understood the calculations involved they are then free to concentrate on comprehending the situation with which they have been presented and applying the right calculation in the context. They may need teaching how to do this but the basis for the work is in place. Only when the problem is “for real”, or as Brown, Collins and Duguid (1989) say ‘authentic’, may it support the understanding of the mathematics, allowing the problem-solver insights beyond those possible when the problem is hypothetical.

### **Pattern within Mathematics**

On pages 34-5, I referred to Baroody’s (1999) work advocating the encouraging of children to see pattern and relationships in number. To my mind this is a real context for their learning because they are focusing on the relationship of the very articles with which they are dealing. He also concluded that children may be presented with activities and games to help them see number combinations and relationships but without having these pointed out or explained to them. When this happens they tend to fail to make the necessary connections. They need to be given time to discover the regularities for themselves and then share their insights in order to help their concept construction. By appreciating pattern within the number system, children can be encouraged to develop flexible ways of working with it, as advocated by Askew and Brown (1997). Such flexibility leads to a command which can be applied to a variety of situations when needed.

### ***The pattern of place value***

When Jay first suggested that we discuss a thousand divided by eighty, I moved to a hundred divided by eight, assuming that he would see the connection between the two. The connection is due to the pattern imposed

upon number by the Hindu-Arabic system with zero which has been adopted by many countries. My assumption was probably unjustified in the light of subsequent conversations we had about place value. What I did do was to explore the subjects with my respondents, finding the drawing of columns a useful visual representation of the patterns, used as a support for oral explanation. A point made by Miles and Miles (1992) was that in their experience children do not always make the connection between apparatus specifically designed to give an understanding of the mathematics, for example the blocks used for base ten. When children are left to use the apparatus on their own and, therefore, to make their own connections then it is possible for them to fail to do so, but they are not so likely to have that problem when it is used to support a verbal input, as advocated by Pimm (1995). I used diagrams to give sight to sound, vision aiding the oral communication as I sought to enhance learning.

When needing to think about place-value columns were used. Jay was asked to write 4275 and wrote 40275. We drew columns and then had a discussion about a digit in the column to the left of another being ten times larger than it would be in the first one. This was an important discussion because as Thompson (1999) says we should be talking of the quantity value of a digit. The excerpt which follows has been quoted before to illustrate another point but I include it again for ease of reference in this context.

Researcher     Would you like to write, underneath that one and above that one thousands, hundreds tens and units?

Jay             Thousands, hundreds, tens and units.

Researcher     OK.

Jay             Thousands, hundreds, tens and units.

Researcher     Good. Now what about the other?

*(He tried and ended up with*                      *thth h t u*  
*4 0 2 7 5)*

Jay                      Um ... you can't put them really in.

Researcher          Mmm.

Jay                      Oh, I'm stuck.

Researcher          Right, do you see, that these two, you wrote that four thousand two hundred and seventy-five, and that is what I asked you to write. Can you now see what you might have done wrong?

Jay                      I put the zero in.

Researcher          You did, yes.

Jay                      So I throw that out.

Researcher          Right.

Jay                      There.

Researcher          And you get?

Jay                      Four thousand ... two hundred ... and er ... seventy-five.

Researcher          Good, and that would be the same wouldn't it?

Jay                      Thousands, hundreds tens and units

Researcher          Now if I was reading that figure, going to write it on a new piece of paper now. Going to write, whoops, have this one, going to write that number ..... as you wrote it to begin with

Jay Um

Researcher And I read it back to you, this is what I would read, forty thousand,

Jay Ohh.

Researcher Two hundred and seventy five.

Jay 22.2.98 pp 3-5

I did not leave the subject there because I needed to ascertain his degree of understanding. We drew columns and named them. Later the conversation went like this:

Researcher That was forty thousand, that was seventy thousand, where would twenty thousand go?

(He wrote:     *t/th   th   h   t   u*  
                  *2    0   000            )*

Jay Twenty .... I know that's wrong.

Researcher Why is it wrong?

Jay Because there's no proper numbers in there ... zeros.

Researcher You can have zeros if there isn't a number.

Jay Good, 'cause I've seen things like that in books.

Researcher Yes, that's right. You have written twenty thousand.

Jay Good, yes.



Researcher But just to help, why did you crowd those three numbers up?

Jay To make it look quite a bit like a thousand.

Researcher I've written those at the top of the columns ... do you think you could write it in columns now?

*(He did.)*

Jay 22.2.98 p.7.

We spent a long time writing two, and the necessary zeros, in different columns up to a million and reading the resultant number. In the example above, Jay had begun to understand the need for being careful with your zeros and the visualising of columns had helped.

I also used columns to address a confusion which I suspected to be present in Gemma. she read two numbers, 410 and 41.0 correctly but when asked to put them into columns she wrote:

h t u  
4 1 0  
4 1 . 0

Because there were three digits in both numbers she put them into the same columns. I decided that I needed to talk about the pattern of how our Arabic

counting system is arranged as well as introducing her to the idea of decimal fractions. So:

Gemma Four hundred and ten

Researcher Oh that's right. Now you've read forty-one point nought, forty-one. If I just wrote forty-one down can you put tens or units above those two, what order? ..... *(She*

*wrote:* T U  
4 1)

Researcher Uh huh, well done. What have you done there? (*Pointing to the diagram given above.*)

Gemma I've put it in the hundreds.

Researcher OK. Try putting it in the right columns.

Gemma Forty there?

Researcher Don't alter. Do it at the bottom. .... OK. What about the point nought. Where does that go?

Gemma Um .. go in the hundreds?

Researcher It doesn't.

Gemma Uggh.

Researcher Oh .. It .. goes .. there ..... What have I done?

Gemma Uhhg.

Researcher Have you done this before?

Gemma No.

I realised that I was assuming a prior experience of working with decimals and a basic understanding. My 'listening' to Gemma's confusion caused me to pause and check.

Researcher No wonder you were looking a bit foxed. Because this goes on with these numbers here. They go on up, but they also go on down as well. How much bigger is a number in that column than a number in that column? Supposing we had thousands, hundreds, tens and units and I put a one in there

and a one in there .. how much bigger is that one than that one?

Gemma Well that is one unit and that is ten.

Researcher Right, so how many times bigger is it?

Gemma Um ..... ten

Researcher Yes, that's right. OK. Let's do that. How many times bigger is a one in that column than a one in that column?

Gemma Well that's in the hundreds and that's only ten now, so the one hundred's bigger than the ten.

Researcher It's bigger than the ten by how many, .... how many times?

Gemma One.

Researcher How many times bigger is a one in the hundred's column than a one in the tens column?

Gemma Ten.

Researcher Ten times bigger than one in the tens column, all right?

Gemma Yes.

Researcher ..... So how many times bigger is a one in the thousand's column than a one in the hundred's column?

Gemma It's ten.

Gemma 19.5.98 pp 9-11

It was not very difficult for her to guess that ten might be the right answer and had they been available this is a time when I might have introduced base ten blocks and discussed their relative sizes with her, “discussed” being the operative word, not just leaving her to use them and make the connection for herself. Eventually Gemma was able to use the column diagram to help her sort a series of numbers into size order and at the end of the conversation about the numbers we had a diagram like this:

TH	H	T	U	.	1/10	1/100
1	0	1	4			
	4	1	0			
	4	0	1			
	1	4	0			
		4	1	.	0	
			1	.	0	4

Fig 4.7 Gemma’s sorting of numbers into place value columns:

In a later discussion Gemma used columns to help her understanding without being prompted. Faced with the problem 6943 - 865.2 the algorithm she drew and then described looked like this:

TH	H	T	U	.	Tenths
6	9	4	3	.	0
	8	6	5	.	2
6	0	7	7	.	8

Fig 4.8 Gemma’s working of a subtraction algorithm.

Researcher      How about you telling us how you did it, Gemma?

Gemma            Well I put thousands hundreds tens and units down here, er tenths for er ..... so I done six thousand nine hundred and forty three, six thousand in the thousands, nine hundred and forty three in the other ones, point nought because there

weren't any points in the number, then I put two in the tenths and then I put the units. five and then six and then the hundreds, eight and then I took them away.

Researcher Uh hum.

Gemma Then you couldn't do nought take away two so cross out the three, put a two there make it ten take away two, eight.

Gemma and Karen 15.3.99 p 2.

She went on to complete the calculation successfully. I cannot claim that our earlier discussion led directly to that successful performance because the time lapse was ten months and her class teacher would have worked with her in between, but the two examples do show a development in understanding. Our oral communication appeared to enhance learning through discussion about a diagram, though that understanding was still incomplete as is shown next.

Another diagram employed was the pie chart which is often used to explain fractions. Again my main point with this is that on its own the diagram has limited use but in the context of supporting discussion it is a helpful tool.

Gemma That's bigger, I think ..... that one in there's bigger. (*She points to the digit in the hundredth column.*)

Researcher ..... That one's bigger. Is it?

Gemma Yeah because that is in tenths and that one's hundredths.

Researcher Hundredths.

Gemma It would be hundred ..... huh, can't say it.

Researcher Right

Gemma            And like it would be one hundred, like hundred.

Researcher       Hundredths. .... If I draw a circle. Watch this. If I draw a circle ..... and that circle ..... divide it into ten, right? I'll do fifths first. I find that easier. OK? Divide it into tenths. .... that one in those (*points to a one in the tenth's column*) is all of tha, is one of those. OK? (*points to a division in the circle.*)

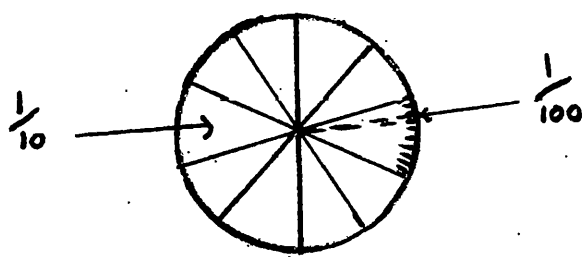


Fig 4.9 Pie chart designed to show the relative size of decimal digits.

Gemma            Yeah

Researcher       But if I draw a circle and divide it into hundredths I've got a hundred divisions.

Gemma            Oh if you draw a hundred in the circle the things would be really li'le. ... Er

Researcher       .... Yes so I've divided one tenth up into hundredths, up by ten, OK? And if I did that all the way round

Karen             You would get a little ..... strip.

Researcher       Yes I would get ten, twenty, thirty, forty, fifty, sixty, seventy, eighty, ninety, a {hundred}

Karen             {hundred}

Researcher So they are hundredths, all right? Follow that?

Karen Yup

Gemma Yes

Researcher So that one in that column represents one of those little strips there, .....OK?

Karen Yup

Researcher Right?

Gemma Yes

Researcher Got it, so something in that column is ten times bigger than something in that column. OK? 'cause there's ten of those in one of those.  
something in that column. OK? 'cause there's ten of those in one of those.

Gemma and Karen 15.3.99 p34  
It would have been very difficult to explain that diagram on paper. It needed to support the spoken word. Although I felt I was operating in Gemma's Zone of Proximal Development (see footnote 2 section 2) at the time, because she had a confusion which she articulated and which, with an input from me, she seemed to start unpacking, she still needed the visual support. This was not the first time we had had a similar conversation so whilst it is possible to see progress within the discussion one exposure may not be sufficient for secure understanding. Regression may occur and oral communication may need to repeat what has been covered in previous conversations if learning is to be permanently enhanced.

Models, such as columns, pie charts and number lines, may well prove useful when a teacher is seeking to explain a concept, but far better is the occasion when a pupil can explain the model for themselves, to make the model their own. It is only then that the pupil achieves 'conscious control' which is essential to Bruner's (1985) idea of 'scaffolding' learning.

### *Exploring pattern in number*

Place-value, as it relates to base ten in our number system, is one important example of pattern within number but when I came to the realisation of a position which advocated an appreciation of pattern and competence in calculation as a basis for problem-solving within situations, I felt that I should explore numerical relationships with the children in a more open manner than the use of models. It also complemented some exploratory work being undertaken in the classroom. Thus, I presented two squares for investigation:

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Fig 4.10 The two squares used as a stimulus for exploring the pattern of number.

Bill and Jay found their own pattern when they looked at the squares and diagonals within a square of four numbers. I used it to prompt them into testing the universality of their find.

Bill                      That says six add two is eight, take away one is seven.



Researcher Yes.

Bill Twelve add eight is twenty take away seven is thirteen.

Researcher Oh that's clever, I hadn't seen that before. Does that work for the others?

Bill Eighteen add fourteen is twenty-two, thirty-two take away

Jay Twelve.

Bill I know going to be twenty, not sure.

Researcher Eighteen plus fourteen, we can always write it, eighteen plus fourteen, ..... is thirty-two take away .....

Jay There we are.

Researcher Yes, nineteen. .... What about the next one?

We continued on with the two squares until I asked:

Researcher Right I wonder if it will work for other squares.

Bill OK, shall we do

Jay Maybe if we do ..... oh. Maybe {if we do}

Researcher {You started} doing the  
seven square. That seven one didn't we?

Bill and Jay 19.4.99 pp 3,4,6.

The square was drawn and examined for the same pattern. We found it, but what I failed to ask was why that pattern always appeared so an important

stage in the thinking was omitted, a stage they could well have embraced because the thinking involved was not very profound. I failed to help them reach the optimum level in their 'Zones of Proximal Development', satisfying myself with the lower level of conceptual understanding, that the pattern occurred in many places, but not discovering the mathematical basis for that pattern. When a teacher is responding to the observations of children it is easy to miss the full opportunities, the 'attributes of the event' as Mercer (1994) calls them, because it was impossible for the implications to have been thought through in advance. However, this does not absolve the teacher from the responsibility of being awake to such opportunities.

Of all that we discussed it was the discovery of that pattern that the boys were keen to share. It had been their discovery, one of which previously I had been unaware. Several sessions later the headteacher of the school entered the room and we turned to include him:

Researcher      We were talking about the patterns you can get.

Bill              Look what we found out!

Jay              We did, look.

Jay and Bill    Six add two is eight.

Bill              Take one away is.

Jay              Seven.

Bill              And then.

Bill and Jay    Twelve add eight.

Jay              Take away seven equals thirteen.

Bill and Jay 24.5.99 p 24

They offered more examples before he responded to commend them. The more children are able to work to their own agenda, the more they are going to remember because their discoveries already connect with their current understanding. They work from that base forward, constructing their own structure, yet so often it is the teacher's agenda to which the pupils work. From my reading of the work of Ernest (1994), I have already written that the skilful teacher will take the insights of pupils and bring them together to show how they fit into a greater, coherent whole. How? In an earlier session Bill and Jay were working out the probability of rolling two dice and getting a total of three, four or five. I did not direct their strategy which was as follows. They decided to write down the possible combinations and add them. They went through each total and added up how many times it occurred and the pattern they produced looked like this:

$2 = 1$   
 $3 = 1$   
 $4 = 2$   
 $5 = 2$   
 $6 = 3$   
 $7 = 3$   
 $8 = 3$   
 $9 = 2$   
 $10 = 2$   
 $11 = 1$   
 $12 = 1$

Fig 4.11 A pattern produced by Bill and Jay during work in probability.

The conversation as they finished went as follows:

Bill            We have now got two tens and how many elevens, one, one  
                  .... twelve equals one ....

Jay            Oh

Bill            Now what do we do?

Researcher     So what's the pattern you've got there?

Jay             So one, one, two, two, three, three, three, ...

Bill             ... Ah, Look!

Jay             Yes.

Bill             One one, no look, one one, two two, two two, three three  
and then they meet in the middle.

Researcher     Mm

Jay             Yes.

Researcher     That's an interesting pattern.

Jay             Yes, yes, yes, yes {yes yes, la, la}

Researcher                        {I suggest it works} because it works out in  
a pattern like that you are likely to have done the calculation  
correctly. We've got a nice pattern.

Jay thought they had finished then and changed the subject so I had to  
remind them of the problem that produced that result.

Bill             ..... Um ..... what now?

Researcher     Well we've got to answer the question rolling two dice and  
getting a total of, what's the odds of getting three four or  
five?

Bill             How many numbers all together?

Jay             One.

Researcher     So ..... you need to know

Bill             Getting a five.

Jay              Yes, what?

Researcher     There's a five.

Bill              Oh, yeah, two.

Jay              Oh yes wha'

Bill              What numbers are they, three four and five?

Researcher     Three four and five.

Bill              So it's one and a two .. aand two, that's ..... five.

Researcher     Five chances out of how many?

Bill              Two, four six ..... nine, twelve, fifteen ..... seventeen  
..... nineteen, twenty, twenty-one. Five out of twenty-one.

Bill and Jay 17.5.99 pp 23-25

I pointed out how the arrival of a regular pattern indicated success in the calculation, a strategy for checking work. I used the work of the children to draw out a facet of which they were unaware. This is an example of how a teacher and pupils might take from each other (Steffe and Tzur 1994). I also acted as their 'vicarious consciousness,' as Bruner (1985) called the activity of holding onto the wider situation for students whilst they dealt with the minutia. In that regard, I was contributing orally to the enhancing of their learning.

Returning to the exploration of the two squares, Karen saw multiplication tables. Gemma had just drawn a six times six square as a continuation of the pattern:

Karen            Miss, miss, I just found out look if it goes down, it's six twelve, eighteen, twenty-four. That's the six times table downwards.

Researcher      So it is. So it is. I wonder if something happens in this one.

Karen            An' then four, eight, twelve, sixteen.

Researcher      Oh yes.

Bert             And that's the five times table.

Karen            Six, four, five, four.

Researcher      Oh yes, that's good isn't it? .... Where else have we got a pattern, got a table like that? ..... I wonder.

Gemma           ..... Here.

Bert             That's not all is it?

It was obvious to me that the vertical lines at the right hand side of each square formed the multiplication tables, but for Karen it was a big discovery and had I not responded with like enthusiasm I would have snatched the moment of enlightenment away from her. She had made the discovery her own, important for the developing of her understanding (Baroody 1999). I supported that by my response and subsequent encouragement to look further, an example of Lerman's (1996) point about a pupil's conceptual structures in relation to the school setting.

Whilst we were looking at the last vertical column in each square Gemma had seen the pattern elsewhere. I moved to listening to her contribution and Karen followed. Gemma moved the thinking to a more complex level and from the ensuing conversation it seems that Karen's understanding was enlarged.

Gemma Yes it is, three, skip a number, nine

Karen No.

Researcher Fifteen in the three times table.

Karen Yes, three nine fifteen.

Gemma Three skip it, nine, skip it, fifteen,

Researcher Oh

Gemma Three times table but

Karen Miss you've got three on there and nine on there.

Bert Yes

Karen Miss we've three on there and one on there. We've got one two three four on that one and just one

Researcher If you're following through three, skip it, skip it nine skip it fifteen ..... I wonder

Karen Look, five, ten, fifteen, five, ten, fifteen,

Gemma I've told her that already

Researcher     Yes that's fine I wonder if we do the two times table. Is there any skips in the two times table?

Karen            Two eight, fourteen, twenty.

Bert, Gemma and Karen 1.3.99 pp 32-34

Right at the end of that conversation Gemma was beginning to think about an important mathematical sequence, but there was not time to develop it which was a great shame. She was talking about the bottom left-hand number in each square:

Gemma          Sixteen and twenty-five,

Researcher     Yes

Gemma          Is nine,

Researcher     Yes

Gemma          Twenty-five from thirty-six ... is nine, I think

Bert            (*indistinct*)

Gemma          That's what happens to the end numbers, you add nine.

Bert, Gemma and Karen 1.3.99 p 36

With a small amount of support she could have corrected her mistake and been encouraged to calculate the sequence of differences between square numbers as follows

1	4	9	16	25	36	49	64	81	100
	3	5	7	9	11	13	15	17	19

Fig 4.12 The demonstration of sequence in square numbers.



The difference increases by two each time. I did not continue the discussion on this point the next time we met, probably because I did not see the potential until I analysed the transcript. Mercer (1994) would maintain that scaffolding a child's learning involves listening to, rather than just hearing what, a pupil says otherwise we can fail to put in the support, albeit in the form of a challenge to think further, at the opportune moment. Listening, in this instance, would involve hearing what was said and relating it to a wider picture.

The extracts of discourse discussed above are used to illustrate the fact that the children seemed to find their understanding enhanced more when their focus was directed at seeing patterns in the numbers system than when were thinking about hypothetical situations. I believe it to be a vital aspect of gaining a grasp of mathematics that the student appreciates the structures and patterns which undergird our understanding of the domain. Approached with this belief it is no longer a mystifying jumble of figures, but inherently a language with its own rules and these rules, structures or patterns can be discovered by any person willing to look for them. Once discovered, the patterns become understandable. At times patterns can be discovered by collating sets of numbers, at others a model or diagram can help. These very structures and patterns begin to make concrete the manipulation of abstract symbolism.

Once a flexible command of numerical pattern is established the understanding can be applied in a variety of authentic, and maybe not so authentic situations.

## PART FIVE: CONCLUSIONS

I set out to investigate my own work with a small group of children in order to gain insights into how my discussions with them helped or hindered their learning, to respond to the question, How can teacher-pupil oral communication be used in the teaching situation to establish and build on pupils' perceived understanding and thus enhance learning? As I read studies of how other researchers and practitioners saw children being helped, I sought to incorporate the insights, alongside my own gained from studying my own practice, into our conversations.

The implications of my work need to be drawn out for the enlightenment of myself, fellow practitioners, whether teachers or assistants, and the wider educational research community.

### **Implications for myself and any practitioner reading this work**

#### *Aspects of the teaching of Mathematics*

The domain in which I was working is a one with very specific concepts which need to be grasped. I found instances (Jay 18.2.98, 17.5.99 and Karen 12.5.98) where some children were distracted from the concentration on those mathematical concepts involved and moved into discussing their experience of the situation when the material was presented to them in the form of a pseudo 'real-life' written problem. This may well have been because the mathematics required of them was inappropriate to that particular situation in the minds of the children, but it still stands as an illustration of the point that children may not see the tenuous connection that the teacher has made between the mathematics and the setting. For them, the situation does not throw any light on the mathematics. I conclude that whilst a person is actually within a situation they may perform mathematical operations beyond their ability to present these in a formal mathematical setting because they see the relationship between the two. Others, such as Brown, Collins and Duguid (1989), have found this to be the case. However, from my experience in working for this dissertation, I

believe that when the calculations are presented as situational problems in the classroom they can become abstract and of less support to the understanding of mathematical concepts.

The need is to make concrete the abstract and I see from my work that it is possible for children to grasp the inherent nature of Mathematics as one of pattern, and this seemed to help them grasp necessary concepts. Discussion was found to be valuable in bringing out patterns and this was enhanced by the use of written modelling, where the visual augmented the aural, but did not supplant it. The evidence examined looked at the appreciation of aspects of place value and the exploration of pattern in number squares. It is limited in scope and on its own gives but a small foundation for the claims made above, but it adds to the work of others and, for me, would seem to indicate that my emphasis in the teaching of number would be the more effective if I encouraged learners to look for patterns.

#### *Aspects of discourse*

The more useful oral strategies for the support of learning used by me during discussion seemed to be speculation and the use of 'wait time'. The first seemed to give pupils permission to hypothesise and explore in return, not always deferring to the authority figure in their midst. I conclude that speculation has an advantage over questioning in that if the adult is not able to make a totally cognitively appropriate prompt the children are not left in the invidious position of not being able to answer. They can accept or reject the comment at will. One of the most valuable uses I seemed to find was when the children had reached an impasse, or were moving from a helpful conceptual path into error, I could provide a new relevant thought without being prescriptive (p 131).

The second, 'wait time', seemed to afford both the children and myself time to organise our thoughts, both to make sense of what was being presented to us and then to plan a suitable response. In my work with the children, I adopted the intention of waiting, holding back from either responding immediately to a comment they made or from following up on my own

question before they had had time to process the implications. My initial reservation in doing this, that pupils would find prolonged silence intimidating, seemed to be unfounded as closer examination of the transcripts gave rise to the impression that a considerable amount of thinking might well have taken place. However, a point which was emphasised was that the pause had to be at a stage where the level of understanding in the children would not leave them without sufficient support during the pause (p 115). I also discovered a need to help pupils give their peers time and space, something which would benefit from further exploration (p 111).

From my evidence I conclude that both open-ended questioning and initiation, response and feedback (IRF) sequences have a place in oral communication in order to enhance understanding but that that place has to be appropriate to the present understanding of the pupil. In my experience, IRF tended to clarify, rather than promote learning (p 100) and that attention needed to be paid to the phrasing of open questions if they were not to confuse (p 109). Open-ended questioning was used by me on occasions to help children reflect on what they had said, as with Gemma and Karen 15.3.99 and Jamie, Rachel and Lisa 5.7.99. It would have been all too easy to accept the first correct answer they gave as evidence of their understanding but further open questioning revealed misunderstanding which could then be explored.

I have considered various strategies for engaging children in discussion during this section, coming to the conclusion that paramount to all is an ability to listen accurately to, and beyond, their comments. Only then can conceptually appropriate inputs be made into the conversation in order to enhance learning. This is the prerequisite for one who would support children as they develop their understanding.

I am currently engaged in the training of classroom assistants, those who can be called upon to work with small groups of children, particularly during the Literacy and Numeracy hours which take place in most primary

schools. I see my work as having relevance for them and I will seek to share my insights for their consideration.

In both my own teaching of children and in the training of classroom assistants I believe my work for this dissertation encourages me to advocate:

- \* concentrating on helping pupils to appreciate the structures and patterns which undergird our understanding of mathematics. In order to achieve this, models will be encouraged, whether they be diagrams or apparatus, to support oral discussion, but not to supplant it;
- \* concentrating on mathematical operations first and then encourage application to life problems seeking to find authentic settings if possible;
- \* speculating in order to steer exploratory discussion without dictating its direction, particularly if this is felt necessary to avoid error, and in order to give pupils freedom to create their own understanding;
- \* consciously pausing during conversations with pupils, giving them time to construct understanding and using that time to consider whether the demands which have been made on them are appropriate to their perceived state of knowledge or understanding;
- \* asking open questions where there is a feeling that pupils have a considerable grasp of the subject under discussion and need to deepen their understanding or set their thinking in a wider context;
- \* using IRF sequences sparingly, where there is a need to give considerable support in order for pupils to move forward and where one feels one has a reasonable grasp on the state of understanding held by the child.

In all, it is the ability to listen carefully in order to formulate strategic responses which is going to help me, or my trainees, to interact most productively with the children with whom we work.

*Additional implications for myself*

These arose incidentally from my work and were not central to the main themes but are worthy of note. In addition to training classroom assistants, I also work with adults learning basic skills numeracy and, whilst not all written above may be directly applicable, I believe the comments below could help in that situation as well.

The first was the matter of appropriateness. Too often I had in mind my own agenda and was not listening carefully enough to the concerns and concepts apparent in communication from the children. There were also times when I did not keep seeking for the exact nature of their understanding and asked them to take too large a step from one thought to the next. Therefore my inputs and expectations were inappropriate, likewise my feedback. The result was to convey to the students that they were failing which discouraged them.

As I analysed the discourse between the children and myself I became aware that I favoured the one more in tune with my expectations, even within groups of two or three. I was ready to accept a solution from one, or at the most, two children and then to move on before the third had developed a secure concept. Again, as mentioned above, this allows such a child to experience failure to understand yet again, encouraging them to avoid future failure by seeking to opt out of participation. Over a short period I saw that happen for at least one of the children.

There will always be the issue of dealing with variety in the pace and direction of concept modification within any group of learners and I need to be aware of the problems and develop further my strategies for dealing with that issue as I work.

On a number of occasions I was too ready to pass on to another subject before children had demonstrated that they could apply their new found understanding (Stones 1992). Bruner (1985) discussed the need for 'handover' and Edwards and Mercer (1987) looked for the time when the pupil took over control for themselves. There were few occasions where I persisted with a topic until that process was complete.

Flanders (1970) wrote about the skill of taking the ideas of pupils and developing them towards learning objectives. This would demand thought about the flexible pathways which can be used to work towards a grasp of concepts. I need to spend time on the necessary preparation and then be confident in being able to pick up points used by pupils.

In future:

- \* I will seek to invite and weigh sequences of inputs from learners so that my responses more accurately reflect the need for support at any particular time.
- \* I will seek to find ways of being inclusive, helping to support the learner who is making rapid progress in formulating concepts in their skills of giving time and space to others, alongside myself.
- \* I will seek to hone my skills of differentiating interactions with learners.
- \* I need to be constantly looking for independent demonstrations of understanding and skills in learners, not being satisfied with assisted performance.
- \* I need to prepare my own conceptual maps for subjects under discussion so that I can develop the ideas of learners towards learning objectives.

### *Implications for other teaching practitioners*

I feel it would be useful for those engaged in teaching to consider the points advocated for myself and my trainees. It may well be that they would find it useful to consciously incorporate some of the strategies into their work and examine whether these strategies might enhance the learning of their pupils.

### **Implications for the wider educational research community**

There are a number of issues, not necessarily central to my main themes, which could benefit from further investigation, either by myself or by others.

### *Aspects of learning*

If we are to improve learning taking place during discourse we have to be able to trace the development of concepts so that successful strategies can be identified. I attempted this, (see p 41), but feel there is much more to learn.

\* Tracing the development of concepts through the progress of discourse could be honed to a considerable extent.

It would take a number of hours of discourse focusing on a small group of children as they worked intensively on one or two concepts or small subject areas. Ideally the conversations would take place over a relatively short space of time so that outside influences on the pupils' thinking were not allowed to have a measurable impact.

I am of the opinion, (see page 37), that if teachers were to steer pupils towards socially accepted concepts while still allowing the children space to formulate the concepts for themselves then it would be necessary for teachers to anticipate the possible thinking of their pupils.

\* Research into how teachers could anticipate possible interconnecting pathways in moving towards a given concept and then how they could use that knowledge to support pupils as they make progress along the pathways.

A possible method of investigating this activity might be to invite some teachers to record on paper the pathways they anticipate their pupils might follow and then to record them working with a few pupils at length. The



resultant discourse could be analysed for the paths actually followed by pupils and then matched to the original prediction.

### *Aspects of the teaching of mathematics*

The appreciation of pattern in number has been a major theme of this dissertation, but the question of how this might be achieved has only partially been addressed.

- \* Further investigation could be made into how best one might take an appreciation of pattern and support pupils in applying it to situational problems within the domain of mathematics.

This would be difficult to investigate but might be attempted through a longitudinal study of a few teachers working with their pupils, sampling both written work and discourse.

I found the need to use written models to support oral input but feel that a further investigation could be made into the strategic use of such models.

- \* Investigate further the role of modelling in the support of oral input.

A study where a single model is used in support of oral input over a variety of situations might be undertaken. That study might take the form of analysed recordings and written evidence.

I mentioned the need to teach the skill of mapping mathematical operations onto mathematical problems in section two, a response to Resnick (1989). It is a consideration which must be a consequence of the position I have taken in relation to the two, but one I was not able to investigate.

- \* How one teaches the appropriate use of known mathematical operations in a problem solving setting needs to be investigated.

Such research might be approached by analysing the facets of the task, and then study recordings of teachers working with the facets in a structured way.

### *Aspects of discourse*

Many of my comments about my use of speculation reveal a use which was illusory rather than having much reality.

- \* Speculation on the part of the teacher was found to be a useful tool in promoting similar exploration of concepts, particularly when there was a need to steer thinking without dominating it, but much more waits to be discovered about appropriate contexts for its use.

A teacher might concentrate on one form of speculation, finding as many occasions as possible on which to use it and monitor the resultant response from pupils.

On one occasion in particular I found myself implying to a pupil that he might pause and give his friend time to compose his answer (Bill and Jay 26.4.99). I feel that an investigation should be made into how teachers could develop such support.

- \* My pupils appreciated being given time and space to digest inputs and to compose their response but a particular issue arose about encouraging their peers to do likewise. I was unable to explore this further.

Recordings of teachers intentionally seeking to help children give others time and space could be analysed for the resultant effect on their pupil peers.

It is advocated that we use open questions to stimulate thought in our pupils. However, I found that even when I did the nature of those questions either assumed understanding or were inappropriate. I believe there is still need to investigate the nature of the most productive open questions.

- \* Investigate the wording of open questioning in order to ensure appropriateness to the understanding of pupils.

A collection of open questions could be gathered from recorded discourse and then matched with perceived understanding of the focus pupils.

## **Dissemination**

Apart from myself there are two bodies of people who could benefit by engaging with issues explored in this dissertation, namely practitioners and researchers.

Two avenues for dissemination to practitioners would be the writing of articles for magazines such as 'Junior Education' which is placed in staffrooms, and the writing of a book which is more likely to be read by those preparing for a teaching career. However, I have at my disposal more immediate avenues. Teachers are not the only people in a primary school who might value engaging with the issues, particularly ones related to discourse. Learning support staff and parents could well be encouraged to give time for thinking, to suppose and to ask open questions. I am engaging with both these groups in the training situation. In addition I have the opportunity to interact directly with the teachers in whose classes they work.

I would also seek to contribute at least one article to a refereed journal, appropriate to the subject of discourse in mathematics in the primary phase of education. In addition, I wish to submit a paper to a research conference so that my work might take its place in the ongoing debate about primary education, particularly in the domain of mathematics. I have gained much from the insights of others and maybe it is now my turn to contribute.

## **Finally**

I set out to investigate the role and nature of oral teacher-pupil communication in the task of establishing and enhancing perceived understanding in the domain of mathematics. As a result of my studies I believe that children need to appreciate the pattern and symmetry of mathematics. The domain involves the manipulation of abstract symbolism, but according to distinct rules, interlocking patterns which make concrete the abstract. I believe that the appreciation of this patterning is aided by the use of apparatus and diagrams, but only as they are accompanied by, or rather used in support of, oral explanation. Once the understanding of, and ability to, manipulate mathematical symbols in calculations, according to

inherent rules imposed by pattern or social instigation, are secure, I am sure they can be used in hypothetical or authentic situational problem-solving.

My studies lead me to conclude that the most vital oral activity in which I should engage is that of listening. I think that it is only as adults in the teaching situation encourage the pupils to explain their understanding and to articulate the development of their thinking that they can gain the insight they need to assess and support the learning. How teachers might then operate orally whilst seeking to support pupils' learning has been at the heart of my study. I examined a controlled strategy of initial question, response from the pupil and the giving of feedback; open-ended questioning; the use of silence and speculation. I found that, when used strategically within a fairly accurate understanding of the child's position, the last two were the more effective. Speculation, I felt, allowed the child to retain independence and use their own thinking whilst the adult is influencing the direction of their thoughts; and keeping silent, for suitable lengths of time, helped children to structure and build on their own understanding.

## Notes

### *1. Scaffolding*

Jerome Bruner (1985) coined the expression, 'scaffolding' when he wrote:

When a child achieves that conscious control over a new function or conceptual system, it is then that he is able to use it as a tool. Up to that point, the tutor in effect performs the critical function of "scaffolding" the learning task to make it possible for the child, in Vygotsky's words, to internalise external knowledge and convert it into a tool for conscious control.

(Bruner, 1985, pp 24-25)

Neil Mercer (1995) is clear on what he sees as this process:

the essence of the concept of scaffolding as used by Bruner is the sensitive, supportive intervention of a teacher in the progress of a learner who is actively involved in some specific task.

(Mercer, 1995, p 74)

and he illustrates this by describing the behaviour of a teacher who encourages a pupil to talk his way through a sequence of operations without telling him what to do (p 77). In Mercer's view it is the telling that ceases to be scaffolding.

There seems to be at least two approaches which writers have used when referring to the giving of support to a learner during the problem solving process. One is the providing of support at first and gradually withdrawing it until the learner is operating independently. An illustration of this is given by Hofkins (1996):

Teachers will be helped to provide more "scaffolding" for children's writing, to provide structures to make sure children consider settings, character and plot organisation in fiction and other relevant aspects of fiction writing,

Hofkins, 1996, p 19)

and also described by Meadows (1993) as the teacher providing all the cognition at first and then slowly withdrawing it as the pupil takes over. The other is the support which responds moment by moment to the degree in which it is necessary at that particular time.

Contingent teaching...involves pacing the amount of help children are given on the basis of their moment-to-moment understanding. If they do not understand an instruction given at one level, then more help is forthcoming.

(Wood, 1988, p 81)

This slight discrepancy appears to be exemplified by Cooper and McIntyre (1996) who say:

scaffolding, then, is the extension to the child's capabilities that is afforded when the teacher instructs the pupil in procedures that enable him or her to employ existing skills in a new way to solve a problem.

(Cooper and McIntyre, 1996, p 117)

We have to ask, "in what kind of procedures is the teacher expected to give instruction?" "Do these come before the child tackles the problem to give a platform of support or are the instructions given as the need becomes apparent during problem-solving?" Cooper and McIntyre proceed to give an example which clarifies their meaning.. Such phrases as "responding to the pupil's own efforts" and commenting on them and by offering action suggestions "that draw on the pupil's ideas" (p 117) indicate a commitment to giving instruction during activity. Without those phrases one has the impression they intend the former, instruction first and then follow it. In any case, I find myself much more

comfortable with the idea that teachers can give instruction and offer suggestions than with those who say that all the pupils must be allowed to build unique constructs of understanding because then the teacher, who also has a unique construct, can only work in conflict with the pupil, never in harmony.

It is the form of support which responds to the moment by moment needs of the learner, increasing or decreasing as necessary, which is the focus of my study.

Instruction consists of leading the learner through a sequence of statements and re-statements of a problem or body of knowledge that increase the learner's ability to grasp, transform, and transfer what he is learning.

(Bruner, 1971, p 49)

I agree with Neil Mercer when he says, "I have some reservations about its [scaffolding] being casually incorporated into the professional jargon of education, and applied loosely to various kinds of support teachers provide" (1995 p 74). Because there seems to be some ambiguity about how the term 'scaffolding' is used, it may be preferable to think of what a teacher does during a conversation with a pupil as 'supporting learning'.

## *2. Zone of Proximal Development (ZPD)*

Whatever the interaction between teacher and pupil, even if it entails the manipulation of concrete apparatus, they will employ language as a means of communication. The Russian psychologist, Vygotsky (1962), would go further and say that language was the key to learning, making sense of one's environment. He would want the teacher to lead the conversation about an experience forward so that the child is supported as they process language in order to focus attention, select distinctive features, analyse and synthesise so forming and reforming concepts. This process is one of taking a pupil from where they are to a new level of understanding.

We will describe a new and exceptionally important concept without which the issue cannot be resolved: the zone of proximal development.

(in Stierer and Maybin, 1994, p 52)

This process, therefore, is given a name: a name, I suspect, which has been used sometimes without total agreement with the way Vygotsky viewed it.

It is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.

(in Stierer and Maybin, 1994, p 53)

So the ZPD operates in the realm of problem solving. Vygotsky goes on to make the point that it depends on the ability of the child at the time of the interaction as to how 'wide' that zone might be. He proposes that

developmental processes do not coincide with learning processes.

Rather, the developmental process lags behind the learning process;

this sequence then results in zones of proximal development.

(in Stierer and Maybin, 1994, p 57)

For him there is a limit on the learning at any one time, imposed by the learner.

## References:

- Ainley, J. (1999) 'Who are you today? Complementary and conflicting roles in school-based research', *For the Learning of Mathematics*, vol. 19, no. 1, pp 38-47.
- Ainsworth, S., Wood, D. and O'Malley, C. (1998) 'There is more than one way to solve a problem', *Learning and Instruction*, vol. 8, no.2, pp 141-57.
- Alexander, R. (1995) 'Task, Time, Talk', in Alexander, R., *Versions of Primary Education*, London, Routledge.
- Alexander, R. (1997) *Policy and Practice in Primary Education: local initiative, national agenda*, London, Routledge.
- Alexander, R., Willcocks, J. and Nelson, N. (1996) 'Discourse, Pedagogy and The National Curriculum: change and continuity in primary schools', *Research Papers in Education*, vol. 11, no.1, pp 81-120.
- Anderson, G. and Arsenault, N. (1998 2nd edn.) *Fundamentals of Educational Research*, London, Falmer Press.
- Askew, M., Bliss, J. and Macrea, D. (1995) 'Scaffolding in Mathematics, Science and Technology', in Murphy, P., Selinger, M. and Bourne, J. (eds.), *Subject Learning in the Primary Curriculum*, London, Routledge.
- Askew, M. and Brown, M. (1997) *The Teaching and Assessment of Number at Key Stages 1-3*, London, SCAA.
- Atkins, M.J. (1984) 'Practitioner as researcher: some techniques for analysing semi-structured data in small-scale research', *British Journal of Educational Studies*, vol. 32, no. 3, pp 251 - 61.
- Attrichter, H., Posch, P. and Somekh, B. (1993) *Teachers Investigate their Work*, London, Routledge.
- Ball, S.J. (1993) 'Self-doubt and Soft Data: social and technical trajectories in ethnographic fieldwork', in Hammersley, M. (ed) *Educational Research: current issues*, London, Paul Chapman Publishing.
- Barnes, D. (1976) *From Communication to Curriculum*, London, Penguin Books.
- Baroody, A. (1999) 'Children's relational knowledge of addition and subtraction', *Cognition and Instruction*, vol. 17, no. 2, pp 137 - 175.
- Bauersfeld, H. (1992) 'Classroom cultures from a social constructivist perspective', *Educational studies in Mathematics*, vol. 23, pp 467 - 481.
- Bennett, N., Desforjes, C., Cockburn, A. and Wilkinson, B. (1984) *The Quality of Pupil Learning Experiences*, London, Lawrence Erlbaum Associates Ltd.
- Bereiter, C. (2001) 'Situated cognition and how to overcome it', in Collins, J. and Cook, D. (eds.) *Understanding Learning: influences and outcomes*, London, Paul Chapman Publishing Ltd.
- Bliss, J., Askew, M. and Macrae, J. (1996) 'Effective teaching and learning: scaffolding revisited', *Oxford Review of Education*, vol. 22, no.1, pp 37 - 61.
- Bonnett, M. (1994) *Children's Thinking: promoting understanding in the primary school*, London, Cassell Educational Ltd..



- Borich, G.D. and Madden, S.K. (1977) *Evaluating Classroom Instruction: a sourcebook of instruments*, Reading, Massachusetts, Addison-Wesley Publishing Company.
- Brown, J.S., Collins, A. and Duguid, P. (1989) 'Situated cognition and the culture of learning', *Educational Researcher*, vol. 18, no. 1, pp 32-42.
- Bruner, J.S. (1971) *Towards a Theory of Instruction*, Cambridge, Massachusetts, The Belknap Press of Harvard University.
- Bruner, J.S. (1985) 'Vygotsky: a historical and conceptual perspective', in Wertsch, J.V. (ed.) *Culture, Communication and Cognition*, Cambridge, Cambridge University Press.
- Bruner, J.S. (1987) 'The Transactional Self', in Bruner, J.S. and Haste, H. (eds.) *Making Sense: the child's construction of the world*, London, Methuen.
- Bruner, J.S. and Haste, H. (eds.) (1987) - Introduction - *Making Sense: the child's construction of the world*, London, Methuen.
- Calderhead, J. (1984) *Teachers' Classroom Decision Making*, Eastbourne, Holt, Rinehart and Winston Ltd.
- Carr, W. (1993) 'What is educational practice?' in Hammersley, M. (ed.) *Educational Research: current issues*, Eastbourne, Paul Chapman Publishing Ltd.
- Carraher, T.N., Carraher, D.W., and Schliemann, A.D. (1985) 'Mathematics in the streets and in schools', *British Journal of Developmental Psychology*, vol. 3, pp 21-29.
- Cazden, C. (1988) *Classroom Discourse*, London, Heinemann Educational Books.
- Chambers 21st C Dictionary (1996) Edinburgh, Carousse plc.
- Chazan, D. and Ball, D. (1999) 'Beyond being told not to tell', *For the Learning of Mathematics*, vol.19, no. 2, pp 2-10.
- Child, D. (1993, 5th edn.) *Psychology and the Teacher*, London, Cassell Educational Ltd.
- Cobb, P. (1994) 'Where is the Mind? Constructivist and sociocultural perspectives on mathematical development', *Educational Researcher*, vol. 23, no. 7, pp13-20.
- Collins English Dictionary (1991, 3rd edn.) Glasgow, Harper Collins Publishers.
- Collins, J. (1994) *The Silent Minority: developing talk in the classroom*, Unpublished Doctoral Thesis, University of Sheffield.
- Collins, J. (1996) *The Quiet Child*, London, Cassell.
- Cooper, B. (1992) 'Testing National Curriculum Maths', *Curriculum Journal*, vol. 3, no. 3, pp 231-243.
- Cooper, B. (1998) 'Using Bernstein and Bourdieu to understand children's difficulties with "realistic" Maths testing: an exploratory study', *International Journal of Qualitative studies in Education*, vol. 11, no. 4, pp 511-532.
- Cooper, B. and Dunne, M. (2000) *Mathematical Knowledge: social class, sex and problem solving*, Buckingham, Open University Press.
- Cooper, P. and McIntyre, D. (1996) *Effective Teaching and Learning: teachers' and students' perspectives*, Buckingham, Open University Press.

- Department for Education and Employment (1998) *The National Literacy Strategy*, London, DfEE.
- Department for Education and Employment (1999a) *The National Numeracy Strategy*, Cambridge, Cambridge University Press.
- Department for Education and Employment (1999b) *The National Numeracy Strategy: mathematical vocabulary*, Suffolk, Beam Education.
- Drummond, M.J. (1993) *Assessing Children's Learning*, London, David Fulton Publishers.
- Edwards, D. and Mercer, N. (1987) *Common Knowledge: the development of understanding in the classroom*, London, Methuen.
- Edwards, A.D. and Westgate, D.P.G. (1994) *Investigating Classroom Talk*, London, Falmer Press.
- Eisner, E.W. (1991) *The Enlightened Eye: Qualitative Inquiry and the Enhancement of Educational Practice*, New York, Macmillan Publishing Co.
- Eisner, E.W. (1993) 'Objectivity in educational research', in Hammersley, M. (ed.) *Educational Research: current issues*, London, Paul Chapman Publishing Ltd.
- Ely, M., Vinz, R., Downing, M. and Anzul, M. (1997) *On Writing Qualitative Research*, London, Falmer Press.
- Ernest, P. (1994) 'What is social constructivism in the psychology of Mathematics Education?' in da Ponte, J.P. and Motos, J.F. (eds.) *Proceedings of the eighteenth International Conference for the Psychology of Mathematics Education, Vol II*, Portugal, University of Lisbon.
- Flanders, N. (1970) *Analysing Teaching Behaviour*, Reading, Mass.: Addison Wesley.
- Gardiner, T. (1998) 'Let's have a Maths Consensus, not Spin', *Times Educational Supplement*, No. 4265, April 3rd.
- Ghaill, M.M. (1991) 'Young, Gifted and Black: methodological reflections of teacher/researcher', in Walford, G. (ed.) *Doing Educational Research*, London, Routledge.
- Gitlin, A., Siegal, M. and Boru, K. (1993) 'The Politics of Method: from leftist ethnography to educative research', in Hammersley, M. (ed.) *Educational Research: current issues*, London, Paul Chapman Publishing.
- Hammersley, M. (1993) 'On the Teacher as Researcher', in Hammersley, M. (ed.) *Educational Research: current issues*, London, Paul Chapman Publishing.
- Hobsbaum, A., Peters, S. and Sylva, K. (1996) 'Scaffolding in reading recovery', *Oxford Review of Education*, vol. 22, no.1, pp 17-35.
- Hofkins, D. (1996) 'Creating the Complete Reader', *Times Educational Supplement*, Sept 6th, Primary Update.
- Hughes, M. and Westgate, D. (1998) 'Possible enabling strategies in teacher led talk with young pupils', *Language and Education*, vol. 12, no. 3, pp 174-87.
- Hunter, J. (1994) 'Learning Multi-unit Number Concepts and Understanding Decimal Place Value', [online], *Educational Psychology*, <http://www.nis.ac.uk/cgi-bin/fetch-mf.pl>. (accessed 7th April 1998).

- Jaramillo, J. (1996) 'Vygotsky's Sociocultural Theory and Contributions to the Development of Constructivist Curricula', [online], *Education*, <http://www.niss.ac.uk/cgi-bin/fetch-mf.pl>. (accessed 7th April 1998).
- Jawonski, A. and Sachdev, I. (1998) 'Beliefs about Silence in the Classroom', *Language and Education*, vol. 12, no. 4, pp 273 - 93.
- Johnson, P. and Gott, R. (1996) 'Constructivism and evidence from children's ideas', in *Science Education*, vol. 80, no. 5, pp 561 - 577.
- Kamii, C. and Livingston, S. (1994) *Young Children Continue to Reinvent Arithmetic - 3rd Grade: Implications of Piaget's theory*, New York, Teachers College Press.
- Kamii, C. and Warrington, M.A. (1995) 'Division with Fractions: a Piagetian, constructivist approach', *Hiroshima Journal of Mathematics Education* vol. 3, pp 53 - 62.
- Kemmis, S. (1993) 'Action Research', in Hammersley, M. (ed.) *Educational Research: current issues*, London, Paul Chapman Publishing.
- Lacey, C. (1993) 'Problems of Sociological Fieldwork: A review of the methodology of Hightown Grammar', in Hammersley, M. (ed.), *Educational Research: current issues*, London, Paul Chapman Publishing.
- Land, F. (1960) *The Language of Mathematics*, London, John Murray (Publishers) Ltd.
- Lerman, S. (1996) 'Intersubjectivity in mathematical learning: A challenge to the Radical Constructivist Paradigm', *Journal for Research in Mathematics Education*, vol. 27, no. 2, pp 133-50.
- Lofland, J. and Lofland, L.H. (1984) *Analyzing Social Settings: a guide to qualitative observation and analysis*, Belmont, C A Wadsworth.
- Meadows, S. (1993) *The Child as Thinker: the development and acquisition of cognition in childhood*, London, Routledge.
- Mercer, N. (1994) 'Neo-Vygotskian theory and classroom education', in Stierer, B. and Maybin, J. (eds.), *Language, Literacy and Learning in Educational Practice*, Clevedon, Multilingual Matters Ltd.
- Mercer, N. (1995) *The Guided Construction of Knowledge: talk amongst teachers and learners*, Clevedon, Multilingual Matters.
- Miles, T. and Miles, E. (eds.) (1992) *Dyslexia and Mathematics*, London, Routledge.
- Moyles, J. (1997) 'Just for Fun', in Kitson, N. and Merry, R. (eds.) *Teaching in the Primary School: a learning relationship*, London, Routledge.
- Murphy, P. and McCormick, R. (1997) 'Problem Solving in Science and Technology Education', *Research in Science Education*, vol. 27, no. 3, pp 461-81.
- Nias, J. (1993) 'Primary Teachers Talking: a reflexive account of longitudinal research', in Hammersley, M. (ed.) *Educational Research: current issues*, London, Paul Chapman Publishing.
- O'Hanlan, C. (1996) *Professional development through Action Research in Educational Settings*, London, Falmer Press.
- Orme, C. (1995) Book Review, 'Constructing Mathematical Knowledge, Ernest, P. 1994', *Cambridge Journal of Education* vol. 25, no. 3, pp 398- 402.

- Phillips, D.C. (1993) 'Subjectivity and Objectivity: an objective enquiry', in Hammersley, M. (ed.) *Educational Research: current issues*, London, Paul Chapman Publishing.
- Pimm, D. (1995) *Symbols and Meanings in School Mathematics*, London, Routledge.
- Pollard, A. and Tann, S. (1993 2nd edn.) *Reflective Teaching in the Primary School*, London, Cassell.
- Ranson, S., Martin, J., Nixon, J. and McKeown, P. (1996) 'Towards a Theory of Learning' in *British Journal of Educational Studies*, vol. 44, no.1, pp 9-26.
- Resnick, L.B. (1989) 'Developing Mathematical Knowledge', *American Psychologist*, vol. 44, no. 2, pp 162 - 169.
- Riches, C. (1997) 'Communication in Educational Management', in Crawford, M., Kidd, L. and Riches, C. (eds.) *Leadership and Teams in Educational Management*, Buckingham, Open University Press.
- Roskos, K., Boehlen, S. and Walker, B.J. (2000) 'Learning the art of instructional conversation: the influence of self-assessment on teachers' instructional discourse in a reading clinic', *The Elementary School Journal*, vol. 100, no. 3, pp 229-52.
- Rowe, M.B. (1974) 'Pausing Phenomena: influences on the quality of instruction', *Journal of Psycholinguistic Research*, vol. 3, no. 3, pp 203-224.
- Rowland, T. (1995) *Vagueness in Mathematical Talk*, Unpublished Doctoral Thesis, Milton Keynes, Open University.
- Rowland, T. (1999) 'Pronouns in mathematics talk: power, vagueness and generalisation', *For the Learning of Mathematics*, vol. 19, no. 2, pp. 19-26.
- Schofield, J.W. (1993) 'Increasing the generalizability of qualitative research', in Hammersley, M. (ed.), *Educational Research: current issues*, London, Paul Chapman Publishing.
- Sinclair, J. and Coulthard, M. (1975) *Towards an Analysis of Discourse*, London, Oxford University Press.
- Smith, D.E. (1958) *History of Mathematics*, New York, Dover Publications.
- Soundheimer, E. and Rogerson, A. (1981) *Numbers and Infinity: a historical account of mathematical concepts*, Cambridge, Cambridge University Press.
- Steffe, L. and Tzur, R. (1994) 'Interactions and Children's Mathematics', in Ernest, P. (ed.), *Constructing Mathematical Knowledge*, London, Falmer Press.
- Stenhouse, L. (1975) *An Introduction to Curriculum Research and Development*, London, Heinemann Educational Books.
- Stones, E. (1992) *Quality Teaching: a sample of cases*, London, Routledge.
- The Open University (1990) *E819 Study Guide: Curriculum, Learning and Assessment*, Milton Keynes, The Open University.
- The Open University (1996) *E835 Study Guide: Educational Research in Action*, Milton Keynes, The Open University.
- The Oxford English Dictionary (1989, 2nd edn.) Oxford, Clarendon Press.

- Thomas, R.S. (1994) 'Radical Constructive Criticism of von Glasersfeld's Radical Constructivism', in Ernest, P. (ed.), *Constructing Mathematical Knowledge*, Lewes, Falmer Press.
- Thompson, I. (1999) 'A Place for Everything', *Times Educational Supplement*, 1st October 1999.
- Tobin, K. (1986) 'Effects of Teacher Wait Time on Discourse: characteristics in Mathematics and Language Art classes', *American Educational Research Journal*, vol. 23, no. 2, pp 191-200.
- Torrance, H. and Pryor, J. (1998) *Investigating Formative Assessment: teaching, learning and assessment in the classroom*, Buckingham, Open University Press.
- von Glasersfeld, E. (1989) 'Learning as a Constructive Activity', in Murphy, P. and Moon, B. (eds.) *Developments in Learning and Assessment*, London, Hodder and Stoughton.
- von Glasersfeld, E. (1994) 'A radical constructivist view of basic mathematical concepts', in Ernest, P. (ed.), *Constructing Mathematical Knowledge*, London, Falmer Press.
- Vygotsky, L.S. (1962 Tr Hafmann, P. and Vakar, G.) *Thought and Language*, Cambridge, Mass, MIT Press.
- Vygotsky, L.S. (1994) 'Extracts from "Thought and Language" and "Mind and Society"', in Stierer, B. and Maybin, J. (eds) *Language, Literacy and Learning*, Clevedon, Multilingual Matters Ltd.
- Walkerdine, V. (1988) *The Mastery of Reason*, London, Routledge.
- White, R. (1992) 'Implications of Recent Research on Learning for Curriculum and Assessment', *Journal of Curriculum Studies*, vol. 24, no. 2, pp 153-64.
- Whittaker, D. (1986) *Will Gulliver's Suit Fit?* Cambridge, Cambridge University Press.
- Wood, D. (1988) *How Children Think and Learn*, Oxford, Basil Blackwell Ltd.
- Wood, D. (1992) 'Teaching Talk: how modes of teacher talk affect pupil participation', in Norman, K. (ed.), *Thinking Voices: the work of the National Oracy Project*, London, Hodder and Stoughton.
- Wood, D. and Wood, H. (1996) 'Vygotsky, Tutoring and Learning' *Oxford Review of Education*, vol. 22, no. 1, pp 5-32.
- Woods, P. (1986) *Inside Schools: Ethnography in Educational Research*, London, Routledge and Kegan Paul, PLC.
- Wright, C. (1993) 'Early Education: multiracial primary school classrooms', in Gomm, R. and Woods, P. (eds.), *Educational Research in Action*, Milton Keynes, Paul Chapman Publishing Ltd.
- Wright, S. (1990) 'Language Counts in Teaching Mathematics', in Webb, R. (ed.), *Practitioner Research in the Primary School*, Basingstoke, Falmer Press.

## **Appendices**

### **Appendix 1: A short extract from one transcript**

This contains several pages of continuous transcript from a conversation with Bert, Gemma and Karen on 8.3.99. References to this particular conversation appear on a number of occasions in the dissertation.

### **Appendix 2: Extracts from a conversation with Bill and Jay**

The pages are not consecutive but have been chosen to illustrate various prompts used by the adult.

### **Appendix 3: Moves and strategies given by the teacher**

This contains lists of the moves and strategies developed by the researcher during analysis of the transcripts.

### **Appendix 4: Year six results in Mathematics**

The results in question relate to the children with whom the analysed conversations took place.

Appendix 1

A short extract from one transcript.

This is from a conversation with

Bert, Gemma and Karen

on

8th March 1999

We were discussing two squares, as seen below, and seeking to identify patterns as well as to use these patterns in prediction.

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

- \_\_\_\_\_ Commentary
- \_\_\_\_\_ Moves
- \_\_\_\_\_ Strategies

T Ten. Can you think if there was any chance you could write down what the numbers might be in that line there if there were ten squares across the top?

A06 Seeks a demonstration of understanding

K Ohhh

T What do you think? You can do it together, you can talk about it.

..... there are ten squares across the top .....

A06 Seeks a demonstration of understanding

B Mm ..... ten squares down.

T And ten squares down, yes

B02 Repeats child's comment

B With ten between each it would be ten twenty thirty forty

T It might, but you've got, each one of those squares starts with a one

B15 States a fact to focus

B Oh

T In that first square doesn't it?

B05 Responds by adding

B Got

T It might, yes, that's a good start, now go downwards without writing the whole lot? ..... If you can work it out.

A06 Seeks demonstration of understanding

B Gonna go ... eleven, twelve

K Oh I get it now ..... It's going like this ... um if you put a one onto that it is eleven, then it goes twelve thirteen fourteen fifteen sixteen seventeen eighteen nineteen twenty

B18 Non committed Response

T {It might do} yes, do you agree?

K {twenty one} A04 Asks for opinion

K Twenty one ... no

G Thirty one, forty one,

Would they have eventually seen the pattern for themselves had I not been so pressing?

Have I helped them to develop strategies for looking for patterns?

A short pause to allow them to think

Bert is processing the question

He is moving in the right direction but the line starts with one I point that out

Bert starts writing out a ten by ten square

I want to encourage Prediction

They still need the support of counting on.

Gemma has been quiet through all of this - but has

no idea and comes in with appropriate numbers.



K Yes ..... Yes

T Mmmm I think you might be right  
B03 confirms child's understanding

K fifty one 16's a pattern

T Mm. It's a good pattern Isn't it?  
B06 makes observation

K Mm

B Twenty one

K Yes

B (indistinct)  
B03 confirms child's understanding

T You're right, are you? ..... I  
shouldn't bother to write them all.  
D08 makes suggestion

K (indistinct)

T 'Cos it'll take a long time to do that.  
B06 makes observation

K (Indistinct)

T OK so, you think it goes one, eleven  
twenty one,

B16 rephrases contribution from  
child

B Um ... twenty nine

K Thirty

B08 correction  
T Thirty one. .... You've got ten lines  
B06 makes observation

K They're going in ones.

K and B (indistinct)

G The unit stays as one and the tens  
keep on going up in numbers

B03 confirms child's understanding  
T Does, doesn't it? How far it go, how  
far is it going to go?

K It must go up to ..... A hundred  
and one,

B eleven

Karen joins in but does  
she understand why Gemma  
said what she did I feel the  
need to encourage at this point

I keep trying to encourage the  
idea of a pattern.

But Bert keeps going with  
writing out the square. I do

my best to stop him because I  
want him to predict numbers,  
not have them written down.

I summarize the answer I  
want but am I too quick?

Bert keeps going. Maybe his  
mind is on doing that so he is  
not thinking about what anyone  
else is saying. I try to give  
a clue in order to help prediction.  
Karen has spotted a pattern

and Gemma continues the  
observation

Still trying to get a  
prediction

Now that is a conclusive  
suggestion

but Bert points out the  
flaw =



T Have a go, see. Just go downwards,  
don't bother about the cross ones.

D09 Repeats instruction

G A hundred and one  
.....

K I told you it was a hundred and one.

B02 Repeats child's comment

T A hundred and one? Is that a ... how  
many lines have you got there?

A06 Asks a question to persuade  
mother about a line

..... eleven, ..... so ten  
would be ninety one.

B02 repeats child's comment

T So ten would be ninety one. I  
wonder what the square might be ..  
what might be in the square, the  
number at the end of the square.

..... Going to take you  
ages to draw the lot.

C03 Extension question  
B06 Karen's comment

K Ahh huh huh huh

T See if you can work it out without  
drawing the lot.

D09 Repeats instruction

K Oh

T Have a look at the last line. ....  
see if you can find a pattern there,  
perhaps.

D03 Karen's suggestion to cope  
with difficulty

G Hang on

K Oh yes there is. That goes five then  
nought, five then nought, and five.

T Yes but how many squares are in  
that square?

A01 Asks a closed question  
seeking a fact

K Five

B02 Repeats child's comment

T Five, and what's the gap between  
those numbers?

A01 Asks a closed question seeking  
a fact

B Five

Why did I say that when  
they were having a product  
discussion? Maybe I was too  
to stop a child from continuing  
to write. I wanted prediction  
Gemma repeats Karen's  
prediction which pleases  
Karen considerably,

but I need to challenge  
answer

It does not take Gemma  
to see why I challenged and  
asked the closed question

I repeat her comment to re-  
the right prediction, and then  
go on to extend the thinking

Still trying to stop the stream  
of predicting from being short

I make my intention more  
specific

I try to suggest a strategy  
for helping with the problem

Pause

Maybe light is dawning -  
she still needs to think

She is on to something  
Why didn't I let her continue

I have brought the conversation  
back to my agenda - embar  
on an I R F sequence



T Sooooo have a look at that one.  
*Do8 makes a suggestion*

K Four, four.

T Four  
*B02 Repeats child's comment*

B 'Slike being

T And have a look at that one.  
*Do8 makes a suggestion*

B Six

K Six

T Six and six, so can you work out that last  
*B02 Repeats child's comment*

B A hundred  
*C03 Extension question*

*B02 Repeats child's comment*

T A hundred you think. Why do you think that, Bert?

*B17 Asks child to elaborate*

B 'cos there's five going across there and going down it's in the five times table and it's the same as that but in the fours, and if you done ten it'll be ten across, it'll be ten times table down.

G I think of an easier way, ten times ten.

T Well done. Yes  
*B04 Commends child*

G 'cos like one, five, you've got five and then you have four, four times four is sixteen

T Uh huh  
*B18 Non-committal response*

G Five times five is twenty five .... ten times ten a hundred.

*B03 Confirming child's understanding*

T It would wouldn't it? ... Yes. ... Do you know, are those special numbers, those numbers, I wonder if they're special numbers. The numbers at the end of the squares.  
 ? See ..... 'cos you've just said,

*C03 Extension question*

*We continue with IRF*

*Karen is responding appropriately*

*What was he going to say?*

*We shall never know because I cut him off*

*We keep going with IRF, building up to the question I really want to ask*

*I point to a salient feature*

*and Bert makes the jump to answering my earlier question*

*Now I challenge a correct answer to consolidate learning and let the others in on the secret*

*He gives a very good explanation of his thinking*

*Gemma now sees the point and makes her contribution.*

*I congratulate her, in fact them both*

*Gemma continues with her explanation*

*So I follow*

*and she completes*

*I confirm, now we getting to square numbers which was my learning intention for the session*



Gemma, that er .. that's four by four isn't it? and that's five by five, an what, ..... and that's six by six, and that's ten by ten. .... Are they special numbers at all, I wonder?

B15 States a fact to focus child's thinking

G Even numbers? thinking

T They're even, ..... they're not all. .... 'cos twenty five isn't even is it?

B15 Responds by adding

G Odd and even

All (confused)

T ..... OK Have - a - go, have a go at draw, at putting dots instead of numbers, but making the shape of that.

D08 Makes a suggestion for coming with

K What so you difficulty

T There  
D09 Repeats instruction

All (laughing)

T that's easier.

B06 Makes observation

K huh hah hah

T Leave it, doesn't matter we can pick it up at the end. OK

F09 comment (not recording)

K (laughing)

D08 Makes a suggestion to come

T Right ..... put do', I wonder, if you put dots instead of the numbers, on here, make the shape of it, put dots..... so that's that'll be four dots down and four dots across. won't it ..... Four and four.

B11 Gives explanation

K Ohhhh ..... there is that right?

I backtrack in order to make sure the context of my question is understood

I don't want to give the answer before I know what the children could supply but it is very much 'Guess what the teacher is thinking'

One attempt - an exception pointed out rather than say

a straight no so Gemma expands the set and ends including all whole numbers

I try to give a way of conceptualizing the answer

I want without giving it

We set off on the task

Bert dropped a pencil

Is this going to detract from their understanding of what I am driving at?

I have to be quite specific

she checks for my approval



B06 Comments child

T That's it and fill in the other ones as well so that you have got a complete square.

B05 Responds by adding

K Finished the square.

T You've finished the square. ....  
not sure it looks like that.

B07 Mild Rebuttal

K We got to do all of that?

T ..... Like this.

B08 Correction

K Ugh

T four, ... four ... then four,

B11 Gives explanation

B I done that.

B11 Gives explanation

T and then four. .... like that. What shape have you got?

B17 Asks child to elaborate

K A square.

T You've got a square. What about  
..... um if you did the five one like that? What shape would you get?

A02 Closed question seeking inference

B Square

K Square, I think a square.

T If you did the ten like that, what shape?

A03 Asks for inferential answer

K I think a square.

T Have you heard of? I wonder if you've ever heard of square numbers?

A06 Seeks for demonstration of understanding

K Yeah

G Yeah

T Have you?

B18 Non-committal response

K Done them last year

There, I've said the word  
will they make the connection

but now we have another  
problem

I have to demonstrate.

Bert is attracting attention  
to his work.

Harving completes my  
demonstration I ask a closed  
question and Karen can  
answer

Now we are slowly building  
again

So I keep going with the  
IRF

Now I make the connection  
for them

They confirm that they  
have heard of Square Numbers



B It's when um there's certain amount of dots um ..... er ..... um

G Um its got a number and its the same ..... did a test.

K Yeah

G It's an eight, square numbers .... find, eight square numbers.

T So what did you have to do?

A06 Seeks demonstration of understanding

B Multiply

G The same number by the same one, the same number you got ..

T So I wonder if that's the same as what you've been doing there.

A10 3 30 sec... Is it the same?

B Ummm

T You said earlier on four by four

B06 Makes observation

K Yes

T And that one's

B11 Gives explanation

G Five by five

B02 Repeats child's comment

T Five by five ..... and that one's there

B12 Adding information

G Six by six

B12 Adding information

T and the next one ten by ten. .... I wonder how many par, how many square numbers we could find.

A10 Speculation

B Could be four by four  
Keep on going for ever

T I wonder, what's the first square number, do you think?

A02 Closed question seeking

G Two inference

K Two

Bert attempts an explanation before I ask

Now it is all coming back to them This is a moment where I hold back and let them tell me what they know

I prod to find out more of what they know

Yes

Gemma adds information

I try to make the connection

Did I wait long enough?

They are not sure about question - was it that which put them off or the maths?

I try to elaborate by going over the ground we have just covered. I do this using I.R.F.

I turn the question round and ask for evidence of understanding of square numbers

Yes

I move away from the evidence with which we have been working. Had the children made the connection



B Four

K Two

B How is two a square?

K Ah!

B04 Commends child

T Good question. Is one a square?

A06 Seeks demonstration of understanding

K Four

T Four

B02 Repeats child's comment

B (Indistinct)

T So four's a square.

B03 Confirms child's understanding

B Four'll be like that.

T So what's the next one?

A02 Closed question seeking inference

K Is six a square?

T I wonder.

A10 Speculation

K ..... nnnno

G Yes

B three

G No

B No

K Yes it is six by six.

T Six by six, yeah

B03 Confirms child's understanding

G That's a square number

B eight

T Yes but the square number is thirty six. .... for six by six.

B12 Adding information

K Ahh huh

Bert has the idea of  
square numbers and demonstrated  
this by challenging the two  
girls.

Am I moving too fast?  
They are not secure with  
ordinary square numbers yet  
The girls respond to Bert with  
a correction

I summarise. We have ignored  
my question for the time being.

I try to build on what Bert  
has established

Karen is happy to suggest  
even though she is not secure  
in her understanding.

We speculate

Karen now makes a valid  
contribution.

I pick it up and use it.

Gemma confirms - but which  
Why did Bert say this?

I correct, assuming he was  
responding to Karen & Gemma.



B Eight six

T Is six a square number, I wonder?

A 10 Speculation

K Ha huh, ha huh

T What about you trying, Karen, can you see if six is a square number?

A 06 Seeks a demonstration of understanding

B I don't think it can be that number. .... It comes out as a rectangle.

T It is isn't it? ..... mm

B 03 confirms child's

K Five?

understanding

T Is five a square number, I wonder?

A 10 Speculation

B No because you've got four and there's one left over.

B 16 Re-phrases contribution from child

T So we've got four as a square number ..... I wonder what our next one would be.

A 02 closed question seeking

B 3 sec ..... Nine

inference

T Nine, how did you get that, Bert?

B 17 Asks child to elaborate

B Done three there, three there, three six nine.

D 07 refers back to previous learning

T So we've got four and we've got nine, they're square numbers

..... I wonder what our next square number might be?

A 02 closed question seeking

K Ten?

inference

T Try ten, do you think ten?

A 08 Asks a question to focus

G No

on his understanding

B (Indistinct) ten be a number.

T ..... 'tis too.

B 03 confirms child's understanding

G Twelve?

I am not sure where that came from either

I try to stimulate further constructive thought, and to

prod an investigatory approach rather than guess

A good answer

I confirm

Guess again

I ask this question to challenge

A good answer again

I recap.

Pause = end there at last the right answer to my question

I seek to find out whether it was a guess or made out of understanding

Bert demonstrates his strength

He really does have the idea

I summarise for the sake of the others

Let's keep this concerning to pattern? Karen makes another guess.

I challenge

Bert elaborates - he has

have written something to

which I responded

Gemma has not grasped the concept



- T Try twelve, see if you can get twelve.  
*D08 makes a suggestion*
- K One two three four, one two three four ..... there.
- T Is it square? ..... absolutely square.  
*A08 asks question to focus his understanding*
- K Yeah
- B {No}
- G {Let's have} a look.
- T No ... Bert, I wonder what you think.  
*A05 seeks for a contribution*
- B 'cause there's four across and three down.
- T four across and three down.  
*B02 repeats child's comment*
- K Nnaarr .....
- B sixteen
- T So try sixteen, let's see if sixteen is a square number.
- D08 makes a suggestion*
- K Yup
- T Ah, so we've now got, what ones have we found?  
*D07 refers back to previous testing*
- B Four, nine and sixteen.
- T OK I wonder which is the next one after that.  
*A10 speculation*
- K .... sixteen
- G Twenty four?
- K Could be

I make a suggestion to help her construct her understanding.

They try out my suggestion

I focus on the reason for the work.

Still the penny has not dropped Bert knows.

I bring him in to help the understanding

He is clear & gives a good answer

I re-inforce the salient point

Bert goes on to demonstrate his understanding

I pick it up and try to get the others to test his theory

Karen confirms, but does she really understand?

Bert is well away.

I push on in order to test progress.

Still not clear.

T Shall we try twenty four and see what we've got? ..... Do you think it is, Bert?

*Do 7 makes a suggestion*

B No.

T Why don't you think?

*Do 8 seeks demonstration of understanding*

B Because it is twelve across and twelve a rectangle.

*Do 5 responds by adding*

T It would be a rectangle then. .... a rectangular one would it? ..... right, so what have we got for the next square number?

*Do 2 closed question seeking inference*

K (Indistinct)

T ..... We've got two, we've got four, rather, and that was two by two, wasn't it?

*Do 6 makes observation*

B Mm

T We've got nine, and that was three by three, got sixteen, that was four by four,

*Do 7 refers back to previous*  
B Twenty five. .... five by five. *Do 7*

T Twenty five, five by five. OK

*Do 2 repeats child's comment*

G Six

T What might the next one be? ..... What do you think, Karen?

*Do 5 says*  
*Do 6 seeks demonstration of understanding*

B Thir'y six

T Thirty six, why do you think that, Bert?

*Do 4 questions to delve into understanding*  
B Because, like four is two by two and then nine is three by three and then sixteen is four by four and then twenty five is five by five

*I suggest testing the answer... but move in too quickly to prod Bert. I ask him*

*to elaborate*

*He is clear, and make the point succinctly.*

*I confirm his thinking*

*Back to square number*

*I pause*

*I recap and explain*

*the pattern, trying to*

*bring out the workings.*

*Still Bert is the one answering.*

*I accept*

*Do we have some light the end of the tunnel?*

*I try to focus on the two girls.*

*But Bert is in*

*Again I try to get him to explain to the girls.*

*He does the recap.*



G and now it six

B Six by six

T Six by six

B02 repeats child's comment

G An' the next one

G and K {will by forty nine}

T {What do you think} the next one, Karen?

A02 closed question seeking inference

G Seven times seven.

B02 Repeats child's comment

T Seven times seven is going to be {forty nine}

All {forty nine}

B Sixty four

G sixty four eight times eight

T eight times eight

B02 Repeats child's comment

B eighty one, nine times nine ..... one hundred.

G That'll be ten times ten

T Um .. and then a hundred ten times ten. We could even go on further

B05 Responds by adding

G Yes

T couldn't we but I think we will stop there. .. Er we've got two times two, I wonder, one times one, we haven't got one times one there.

C03 Extending question

G 'cos you can't do it with ordinary square numbers its one

T Would be one wouldn't it well actually it is called a square number, even that because it's one times one, but you're right

B12 Adding information

G Yes

Yes, is it coming?

We re-inforce.

Maybe we're getting there

A move forward.  
Keep everybody on board

Now Gemma joins in explaining

And we have a chorus  
Are we winning?

Still Bert in the driving seat

Gemma alongside now

I confirm

Too enthusiastic.

checked by Gemma

I confirm

Now I come back to the earlier question which was much too soon. I elaborated putting the point in much more detail.

Gemma is using the knowledge gained above.

I have to just tell them, agreeing the anomaly.



T It's a funny one isn't it? .... It's only got one. OK Uum .... Bert you were talking about a rectangular number. I wonder whether rectangular numbers are odd or even, always odd, always even or sometimes one sometimes the other.

F03 change direction

K Even and odd?

T You think they're even and odd, Karen. .... I wonder what rectangular numbers are. .... are they odd or even?

A03 ask for inferential answer

K 3 see ..... They're odd I think.

B I've got one even though.

T You've got an even  
B02 Repeats child's comment

B Cause three and four across.

T ..... Mm ..... Shall we think if we can think of any odds. .... I wonder if there might be. ....  
10 see  
rectangular numbers that are not square numbers.

13 see  
something to think about isn't it?

A10 Speculation

G They wouldn't be like two times two three times three 'ud be like four time three or something like that, four times five

K Yes

G One two times three. .... they just be like four times three or

B Odd times an even

G Odd times an even

T Um...um when you've got an odd times an even does it end up as an

Now I move the conversation on to a new idea. It is possible that

Karen still is not clear.

I pick up on two of the

points made by the children

in order to focus on a

development. Karen at

usual a quiet answer, w

out full understanding.

Why did she think that

Bert points to a flaw in her argument

I pick up what he says

re-inforce. Bert elaborates

I make a suggestion to help eliminate.

I wait.

Add information

wait

Make a calming comment

Maybe Gemma is getting

there

Karen follows

Yes, she has the idea of

rectangular numbers.

Bert is thinking constructively

Gemma echoes - why? D

I give her enough time to

digest what she was say

before directing the thinking



odd or an even I wonder?

7 sec  
A 40 Speculation

G Even?

T ..Yyes, would be worth seeing if we could find an odd one wouldn't it?

A 10 Speculation

B I've got an even as well.

T I can only think of even ones at the moment. .... Can you think of any odd ones, Karen?

A 10 Speculation

K Mmm ..... 10 sec  
twelve.

T Twelve, thats... even isn't it?

B 08 Correction

G Its um odd by an even. .... four by three.

T Yup

B 03 confirms child's understanding

B (indistinct)

T Have we found an odd yet?

A 06 seeks for a contribution

K Could you have five?

T Five ... does that make a rectangle?  
..... let's look and see.

A 08 Asks question to focus on his understanding

K I've made a odd number.

T What's that one?

B 17 Asks child to elaborate

K {Six}

B {One} two three four five

G Five ... by three .. fifteen

K Oh yes

T That's one, yes, you have.

B 03 confirms child's understanding

B The three's odd and so is five.

G Yes

Pause

An appropriate response

Suggesting a way of checking, in order to encourage strategic thinking.

Bert comes in with support

I agree with them but still want them to check and be sure

thinking time, -

I point out that the answer does not help but Gemma comes in to Karen's support

I agree.

Still prodding.

She has an odd number but does it prove an exception to our rule?

Still trying

Does she know what an odd number is?

Gemma uses her answer to prove the point. Yes you can have an odd rectangular number.

Bert completes the statement.

**Appendix 2**

**Extracts from**  
**conversation with**  
**Bill and Jay**  
**26th April 1999**

These are included to illustrate a point made about prompts.



B So if that's sixty, that's seventy thirty, seventy, thir.. ty five No, yes Thirty five

T Uh hum ..... (8 sec.)  
B 01 Accepts without further comment

B Um thirty, what was the number?

J Seven thousand

B No nine hundred .....  
thirty five point eight I think it is  
..... it is

J Is it? ..... Oh yes.

T Is it?

C 03 Extension question

J & B Yes

B Thirty four point eight.

J Yes

T Could try that or just jot it down see if you and check.

A 10 Speculation

B Because you thirty five point eight ..... so are we adding these or taking away? .....

T Taking them away

B 09 Gave hasty answer

J Twenty one point two I got

T Right, so if we're going to follow this pattern it's then that number ... take away that number.

F 10 Explanation of situation

J Yes so twenty one point two ..... and what ..... do you have the number?

B Six thousand one hundred.

T Yup

B 01 Accepts without further comment

I think Jay was proved  
Bill is still busy  
calculating.

He needs some support  
holding on the whole question  
That was one of the numbers  
but not the one Bill  
wanted. This is an  
interim stage

and I am not going  
to commit myself.

Bill repeats his answer

I want to hold onto it  
and check it out.

He has forgotten what to  
do next - having lost the  
whole picture.  
and I have to prompt him

Jay makes his contribution

I repeat what I said earlier  
but now applying it to the  
calculation in hand.

Jay continues his  
calculation.

Bill helps.

I confirm.

B Five times three and add two noughts

Bill explains

J .... Oh yes

Jay is now happy over that

B five times twenty one

Bill moves on

J Hundred and seven times five

Jay seems to be going his own way.

B thirty five.

J How you add all of them together?

Now this is the tricky part

B Add three hundred and seventy

but Bill has an idea

J ..... no I add .... I added those up together.

This was not what Jay did last time

B Let's do that

Does Bill go for Jay's way?

J and then I added it across..... is a hundred and five ..... hundred, five?

Jay explains what he did

B now Three thousand two hundred and seventy ..... I would do it the other way I'm doing it across way, Jay.

Bill explains what he is doing

J ..... Oh

B A hundred and seventy

Gives an answer

T you can either do it downwards first or crossways first.

I confirm the opinions of both of them + give permission for either.

A07 ~~Extends child's freedom of response~~

B One thousand

T Whichever way you like.

A07 ~~Extends child's freedom of response~~

B One thousand six hundred and thirty ..... five.

Bill has an answer again

J (indistinct) ..... five ten .....

B Four nine oh five I got.

That is his answer

T I am not sure I am with you.

but I am not sure I agree.

A06 ~~Requiring child to be more specific~~



J Oh, so

B should be one oh nine

J Oh, I was getting .... {thought that}

B {(indistinct)}

J Yeah you did.

B Three five three nought .... take away is nought one take away is three

J Isn't ..... yes it is. .... Oh yes, sorry I'm getting

*B03 confirms child's understanding*

T So that's one, how many have you got to think of? ..... Sss

*A01 closed question seeking*

B Some

T some, so try a more difficult one.

That was very easy that was.

*A06 seeks demonstration of understanding*

B OK so let's try

J (indistinct) .... One hundred point nine five

B Yeah

J and then one oh nine

B thirty five

J Then put the answer which is five add five is ten then nine add three nine ten eleven twelve, thirteen, then dot and you've got nine so that equals ten then zero zero ..... four add one is five so it's {twelve hundred}

T {So the subtraction} sum is going to look like

*A02 closed question seeking*

J four hundred

B It'll just be take away

Is he getting it right now

He is still working with the difference in the sum but it is a necessary stage.

Jay now sees.

Obviously I am now satisfied.

I try to increase the requirements.

Start with the difference

Bill allows Jay to lead

He answers Jay.

Jay makes progress.

I remind them of the task

Jay sets about answering but Bill is impatient.

**Appendix 3****Moves given by the teacher during a conversation with a pupil.****A Prompts requiring a response.**

- A 01 Asking a closed question seeking a fact,
- A 02 Asking a closed question seeking inference
- A 03 Asking for inferential answer
- A 04 Asking for opinion
- A 05 Seeks for a contribution
- A 06 Seeks demonstration of understanding
- A 07 Extends Child's freedom of response
- A 08 Asks a question to focus child on a misunderstanding
- A 09 Refusal to accept child's "I can't"
- A 10 Speculation

**B Direct response to pupil contribution.**

- B 01 Accept without further comment
- B 02 Repeats child's comment
- B 03 Confirms child's understanding
- B 04 Commends child
- B 05 Responding to contribution from child by adding to it
- B 06 Makes an observation
- B 07 Mild rebuke
- B 08 Correction
- B 09 Gave factual answer
- B 10 Answers child's question, trying to clarify lack of comprehension
- B 11 Gives explanation
- B 12 Adding information
- B 13 Repeats child's comment but in such a way that indicates the child might like to correct it.
- B 14 Tells child they do not agree with child's solution
- B 15 States a fact in order to focus child's thinking
- B 16 Rephrases contribution from child
- B 17 Asks child to elaborate on what they have said
- B 18 Non committal response

**C Moves the conversation forward through questions**

- C 01 Asks an unconnected question
- C 02 Asking for more information - open question
- C 03 Extension question
- C 04 Asks an open question to delve into child's thinking process

**D Moves when a child is not displaying required understanding**

- D 01 Repeats question
- D 02 Tries another question, the same status as before
- D 03 Asks another question, a variation on the first
- D 04 Turning an inferential question into one asking for fact
- D 05 Asks a question implying that previous contribution from child was not right
- D 06 Requiring child to be more specific
- D 07 Refers back to previous teaching
- D 08 Makes a suggestion for coping with a difficulty
- D 09 Repeats instruction

**E Makes use of reading cues**  
(Used in E835)

- E 01 Uses picture to test factual comprehension
- E 02 Using a context cue to help a child
- E 03 Encourages use of phonics

**F Conversation moves**

- F 01 Intended to calm child
- F 02 Teacher thinking time
- F 03 Change direction
- F 04 Returns conversation to previous point
- F 05 Prompt
- F 06 Eliciting agreement from the child
- F 07 Command made in order to try to clarify child's understanding
- F 08 Agrees with child's agenda
- F 09 Comment for recording
- F 10 Explanation of situation.
- F 11 Restatement of case

## Appendix 3

**Strategies employed by teacher in conversation with pupil.**

- $\alpha$  Goes with child's interest
- $\beta$  Initiation, response, feedback
- $\gamma$  Makes child explain their thinking
- $\delta$  Summarises progress
- $\epsilon$  Drops to a less demanding task
- $\zeta$  Adopts situated cognition
- $\eta$  Reflects back to the child their understanding of what the child has said
- $\theta$  Teacher challenges
- $i$  Double checks a right answer by asking for thinking
- $k$  Initiates a new strategy for work
- $\lambda$  Teacher explains and continues to explain until child responds with understanding
- $\mu$  Support at the point of understanding
- $\nu$  Step by step explanation
- $\xi$  Allows child to demonstrate
- $\omicron$  Teacher gives solution
- $\pi$  Teacher gives praise
- $\rho$  Seeks specific demonstration of understanding
- $\sigma$  Child aware of own deficiencies, teacher praises
- $\tau$  Question at point of misunderstanding
- $\upsilon$  Teacher and pupil building on the point made by the other
- $\phi$  Teacher prevents child from making an error without taking a lead
- $\chi$  Keeps silent, waits
- $\psi$  Speculation

**Appendix 4****Year Six results in Mathematics**

	<b>Teacher Assessment Level</b>	<b>Standard Assessment Test Level</b>
Bert	3	4
Bill	5	5
Gemma	3	4
Hayley	Left School	
Jamie	3	3
Jay	3	3
Karen	3	3
Lisa	4	4
Rachel	4	4